# Knowledge, truth, and schooling for social change: Studying environmental education in science classrooms

by

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A dissertation submitted in conformity with the requirements

for the degree of Doctor of Philosophy

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Doctor of Philosophy (2012)

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**Abstract**

While recent research trends in science education have focussed the collective attention at utilizing the science curriculum as a means towards positive social change, such efforts have largely been predicated on understandings of the nature of knowledge and truth as socially constructed entities. Through this lens of social constructivism, knowledge is said to bear the signature of individuals and institutions in power, and therefore extant knowledge is considered to be the vehicle for further oppression of disadvantaged groups. There are at least two ways in which this argument is deeply flawed—social constructivism accords to itself epistemic positions it denies others, and an intellectually honest application of its principles leads to a position where there is no way to distinguish between better or worse positions on issues. In contrast, the principle of social realism takes a 'middle path', acknowledging the social reality of knowledge construction but disavowing the relativism of social constructivism. Through this epistemological foundation, implications arise for curriculum theory—how is it that we may discriminate forms of knowledge for in/ex-clusion into the school curriculum? In this study, I consider the curriculum changes in the Ontario elementary science anxd technology curriculum. I ask two key questions: (i) What are the effects of the curriculum revisions on the knowledge content of the science curriculum? and: (ii) What are the

characteristics of science pedagogy in fulfilment of these curriculum changes? I develop instruments to analyze curriculum documentation, and classroom pedagogy. The major findings of this project include: (i) the curriculum revisions have added environmental knowledge expectations with varying degrees of disconnection from the scientific content knowledge; (ii) knowledge expectations removed to accommodate environmental expectations constituted important scientific principles; (iii) environmental pedagogy in science classrooms reflected the disconnection between science and environmental knowledge, most obviously in the upper grades where the degree of boundary maintenance between knowledge forms was strongest; (iv) this disconnection between environmental and scientific knowledge forms inhibited the cumulative modality of knowledge (re)production. A discussion of results and the general principles of the importance of knowledge concludes the project.

## Dedication


This work is dedicated to my Partner, Serene Ong, whose numerous sacrifices allowed this project to see fruition

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# Chapter 1
# Introduction

On an unseasonably warm day for winter in 2012, prominent educator and academic Allan Luke gave a talk at a seminar room in OISE. Few people are ever unimpressed after listening to Allan—his breadth of knowledge and his seemingly effortless ability to connect dense theories with accessible empirical phenomena made many converts to his ideas. This session, he was taking a retrospective view of the work he had done in education, ranging from his time as a classroom teacher in Burnaby, British Columbia, to his stint as Deputy Director-General of Education in Queensland, Australia, to consulting for the Thai government, and his leadership in a large scale ($49 million) educational research project in Singapore. In his recounting, one recurrent problematic for him had been locating and working on the 'point of determination'—the point about which social inequalities could be said to be (re)produced by the education system. In not quite so elegant language, the problem was thus: considering the social inequalities extant in society and the role education played in the (re)production of social inequalities, about which point should one apply effort in order to effect the most ameliorative change to the material social outcomes for the largest amount of participants in the education system? For him the answer lay in the classroom—largely because that was where the 'broken telephone game' of educational policy translation ends. In his experience, the many intermediary layers between the political leadership of school systems and the classroom far too often meant that ostensibly well intentioned policies translated into contradictory effects where it matter most.

On a much more modest level, this study is directed towards similar ambitions—at using the currently unfashionable 'old time' enlightenment metanarrative (Siegel, 1997) of changing the world through expanding our knowledge about the natural and social worlds. Given the numerous perils and tragedies of life in contemporary times that we seem to be inundated with on a daily basis (and to which many have taken a fatigued, practically apathetic stance towards) it has become almost second nature to think that schools should 'do something about it'. This study is an exploration into the question—what *can* science classrooms do about it?

## 1. Locating the study

While efforts to reform societies through the institution of schooling are certainly not new, the underlying motivations change from time to time, often along with changes to our understanding or appreciation of the inter-relationships between knowledge, schooling and society. In the recent twenty years for science education, there has been much attention paid, in turn, to the conceptual, epistemic, and social learning goals of science (Duschl, 2008). Along with a wider acceptance of the necessity of schools to participate in educating students about environmental concerns (Palmer, 1998), and a general acceptance of the compatibility of school science as a vehicle for learning about environmental concerns, it should come as no surprise that there has been enough academic interest to support the (fairly) recent founding (in 2006) of the *International Journal of Environmental and Science Education*, along with an increase in journal submissions relating environmental education in the context of science classrooms.

In parallel, but mostly in school subjects other than the science, social reform efforts have been directed toward the remaking of curriculum in ways that were seen to be more equitable to various oppressed groups, based on a realization around the 1970s that since knowledge is socially

constructed, curriculum knowledge tended to reflect the interests of the dominant classes. This perspective, founded on the philosophical principles of social constructivism, and emboldened by various postmodern interpretations of the nature and possibility of truth, reality, and the purposes of schooling (see, e.g., Derrida, 1998; Foucault, 1977; Lyotard, 1984), has witnessed a gradual erosion of the edifice of school knowledge as a necessary consequence of some fundamental relation between knowledge and reality; in other words, school knowledge, or knowledge in general for that matter, was increasingly viewed as arbitrary constructions of powerful groups—white, wealthy, men, for example.

Approaching the turn of the century, contrarian voices grew in amplitude, pointing out, among other things, an essential knowledge blindness of the social constructivist/social constructionist and postmodern philosophies; a recognition that these approaches provided little else beyond a critique of existing hierarchies; and crucially, a self contradictory position in claiming for itself what it denies for others (see chapter three). Social realism, the philosophical movement bearing candidate replacements for ontology and epistemology, argues instead that simply because we can locate the ostensibly arbitrary cultural bases for knowledge claims does not invalidate the truth value of *all* knowledge claims. For social realism, the social is the source of objectivity, and techniques like competitive cross-validation remain as epistemic virtues that ensure impartiality, but do not necessarily guarantee it.

Returning to science education, one implication of these philosophical meditations is that there exist knowledges which are non-arbitrary; these knowledges offer us superior explanations to describe reality, and unless we wish to continually 're-invent the wheel', there is value in privileging the acquisition of *powerful knowledges*—that which possesses a higher degree of correspondence to

reality, and the possession of which affords the acquirer a fuller participation in social, political, and moral debates. To be certain, these arguments are arguments for curriculum, and in no way places boundaries on pedagogical strategies—just because there are superior knowledges that deserved to be acquired, does not mean that an optimal pedagogy is didactic or disrespects the learner as an individual in any way.

In Ontario, changing political winds have caused corresponding changes to environmental policy, and in education, revisions to curriculum to reflect these changed sociopolitical realities, as will be detailed in a later chapter. With these philosophical foundations, for this study, the research questions become:

- What are the effects of the curriculum revisions on the knowledge content of the science curriculum?

  – Comparing between the current version of the elementary science and technology curriculum with its immediate predecessor, what is the nature of changes made to the curriculum?

- What are the characteristics of science pedagogy in fulfilment of these curriculum changes?

  – Considering the influence of the curriculum document on classroom pedagogy, what are the effects of teachers satisfying the curriculum expectations on the level of scientific knowledge in the classroom?

## 2. Thesis overview

This thesis is in nine chapters, with this introduction being the first. In chapter two, I will review some of the research in science and environmental education that argue for science

classrooms to take on the responsibilities of social change in a more direct fashion. Because these arguments make claims about the social utility of changing science curriculum and pedagogy, there is a need to consider the historical precedents in attempting to change society via these means. To that end, chapter two is also concerned with an introduction to the historical narrative of the sociology of curriculum beginning in the 1970s. This recounting brings us to recent thought in sociological perspectives concerning the knowledge blindness that seems to have afflicted the movement.

To deal with these issues in substantive detail, chapter three surveys the movement of social realism, beginning with a critique of a rhetorical strategy referred to as the 'discourse of voice'—in brief, philosophical constructivists and postmodernists have made self-defeating claims in their critique of 'master narratives', and their claims of 'giving voice' to oppressed groups. Chapter three continues with a review of recent work by Michael F. D. Young, Basil Bernstein, and Karl Maton, in a trajectory of increasing specificity of theoretical description of empirical phenomena. Young's work deals with the nature of powerful knowledges, as opposed to knowledges of the powerful in the Marxian sense. The work of Basil Bernstein provides powerful conceptual tools to think about the inter-relationships between schools, societies and structures of knowledge. Building upon the ideas of Bernstein and others, Karl Maton developed Legitimation Code Theory (LCT), which serves as a highly flexible device to 'see' empirical phenomena. Specifically, I make use of the LCT dimension of semantics to characterize knowledge propositions in the curriculum document and segments of pedagogy in the classrooms studied.

In chapter four, I review the methodological considerations underpinning the empirical study, and describe the problem context. This study is based in Ontario, where a recent revision to

the science and technology curriculum has been motivated by the desire to improve the teaching of environmental education throughout "all levels, and all subjects", as recommended by the curriculum review panel. For the classroom study portion of this research, three teachers participants were recruited from a major city in Ontario. Two of these participants (Alice and Bob—all names are pseudonyms) were formerly participants of a professional learning community (PLC) designed to facilitate their curriculum planning and implementation of the revised curriculum. The third participant, Clara, was a part time Masters in Education student, and had taken courses dealing with environmental education in science classrooms. A major part of this study is the development and use of an *a priori* content coding system. Details of this instrument will be discussed in chapter four.

The major task of chapter five will be the presentation and discussion of results from the curriculum analysis segment of this study. After coding text units, basic quantitative analysis methods will be applied to the coding results in order to reduce the data 'bandwidth' for discussion. Comparisons will be made between the older and revised curricula for context dependency and symbolic condensation, between strands in the elementary curriculum. Comparisons will also be made between the expectations in the older curriculum 'relating science and technology to the world', and the revised equivalent of 'relating science and technology to societies and the environment'. As a preview, a major finding in this chapter will be that the revised curriculum has significant losses in scientific content; increased context dependency of learning objectives; and a reduction in symbolic condensation, i.e., concepts become, to use a potentially troubled term, less intellectually demanding in the newer curriculum.

The next three chapters will deal with each of the research participants in turn, discussing issues that arise from each of their teaching contexts. Alice is a grade 4 teacher-librarian, and her pedagogy highlights one essential problem that seems to accompany environmental education pedagogy—the inculcation of a crisis mentality when discussing the dimensions of tragedy, malfeasance, and ignorance associated with anthropogenic environmental degradation. Bob, a grade 7 science teacher, emphasized student 'engagement', and saw environmental issues as a way to contextualize and increase the relevance of abstract "book knowledge" to the "real world". In chapter seven I discuss what may be certain limitations of such an approach to science pedagogy. For Clara, a grade 11 university-track chemistry teacher teaching in an officially designated inner-city status high school, ethnicity and schooling were issues that were discussed from a very early phase of the study. Large numbers of the school population were visible minority persons, and many of these students were also recent migrants to the country. Being a child of migrants and a visible minority person herself, Clara understood her students' motivations and underlying cultural philosophies towards schooling and education. Clara's class prioritized knowledge acquisition, and environmental pedagogy was disconnected from scientific knowledge, leading students to pay less attention to it unless there were academic consequences.

Lastly, I conclude this thesis in chapter nine, where I discuss limitations to this study, and possible avenues for extending this research. A primary limitation has been a change in theoretical framework—the initial framework was considered insufficient, and an alternative was developed post (classroom) data collection. While the revision in framework was not radical, steps were put in place to strengthen this study, including designing and implementing the curriculum content analysis as an organic outgrowth of the new framework. I also discuss the implications of this study for

curriculum theorizing, specifically reflecting upon the importance of knowledge, and the issue of learner identities in schooling.

# Chapter 2
# Curriculum advocacy and social theory

## 1.     Introduction

It should come as no surprise that scholars in science education advocate for curriculum change; it is perhaps a vital part of the work of scholarship that as knowledge advances on the quintessential problematics: What knowledge is of most worth, and, How should we teach it, such knowledge is shared with the intellectual community and implemented by pedagogues alike. Considering the fashions in curriculum and pedagogy over the last several decades, the answer has ranged from conceptual change theories (Posner, Strike, & Hewson, 1982), to constructivist perspectives to science education (Tobin, 1993), to the nature of science (Abd-El-Khalick & Lederman, 2000; Lederman, 1992). In the last decade, the question that has captured the imagination of notable scholars has been the social implications of the teaching and learning of science, bolstered by theories of knowledge based on poststructuralist accounts of the interaction of power in societies, and a heightened awareness of increasing disparities and injustices in contemporary communities. However, reflecting on the central problematics in the opening sentence and most of the curriculum proposals, there appears to be an insufficient analysis of what I would consider the central term of a sufficiently rigorous study in curriculum—that of knowledge. Specifically, while there have been widely accepted arguments regarding the sociality of knowledge in terms of its (re)production, there is sufficient evidence to reconsider some of the more radical implications of these perspectives, if not to abandon the perspective completely.

In this chapter, I want to begin a process of successive theorizations, starting first with an introduction to some selected proposals in science and environmental education. The selection of

these proposals has certainly not been neutral; these proposals are selected primarily for their strong advocacy of an alternative vision for societies and the role of education in this new order. I will then introduce the work of Michael F. D. Young, whose recent (2008) work will serve as an entry point for the introduction of more sophisticated concepts in epistemology, the nature of truth claims, and sociological theories of knowledge. To preview his argument, Young asks: (i) what is the distinction between school and non-school knowledges? (ii) what is the nature of knowledge, in the first place? and (iii) does the nature of knowledge place any necessary limitations on the transmission or acquisition of knowledge?

In order to put these developments in perspective, I will rely on historical recountings, by noted commentators, of philosophical and rhetorical positions in the sociology of knowledge in the last forty or so years. This is necessary as I wish to show that there are positions which have been found to be untenable, superseded by positions expressed by Ladwig, Young, Moore and Muller, and several others by the turn of the century. However, these latter positions have yet to gain widespread acceptance outside of the sociology of knowledge, let alone application in mainstream educational research contexts. Central planks of these outmoded arguments have been the critique of mainstream educational research as positivistic, and that knowledge claims are relative. These apparently innocuous ideas have significant implications for forms of science and environmental education that attempt to make changes in the social organization, and the recent revisions are even more crucial if real changes are to be made at a wide enough scale.

## 2.    Contemporary arguments for curriculum change in science

Of the trends in science curriculum advocacy in recent years, perhaps the idea that has most captured the imagination of researchers has been the use of science as a means toward direct, radic-

al social change; and conversely, learning science through the process of taking action with regards to social issues impacting learners. The popularity of these proposals have even seen the publication of a special issue in the *Canadian Journal of Science, Mathematics and Technology Education*. Calling for readers to recognize that "pedagogic actions and knowledge always generate consequences and carry wider implications" (Alsop & Bencze, 2010, p. 178), the special issue editors state that there have been much recent attention in activist conceptions of science education, which researchers have termed as the "reconstructivist current", given its roots in social constructivism. As a means to describe the current breadth of thought about what I will term here as radical/activist science education, the table of contents of the special issue presents a fair summary of the current thought in the field: (i) Hodson (2010) reiterates a version of his earlier call (Hodson, 2003) for science to recognize its role in the economic apparatus of nation states, a role that has for the most part, ignored or deliberately trampled upon the long term prospects for the wellbeing of societies and individuals; (ii) Elshof (2010) paints a bleak picture of the current state of the environment and how science and technology education has been a complicit party by omitting critical perspectives in the science classroom; (iii) Roth (2010) describes the learning of science through its use in social-liberatory and environmental-stewardship contexts, and proposes instead that science should be learnt through activism; (iv) Barton and Tan (2010) describe alternative subject roles for students in low-income and African-American populations through their active participation in a school greening project. In this section, I will present a detailed appraisal of the state of thought in radical/activist science education, before moving on to discuss its philosophical underpinnings in the next section.

To reiterate, the concern has been with the state of our natural and social/psychological environment, how science and technology has played instrumental roles in the construction of the status quo, a re-imagining of a social reality, and how science education needs to work towards the achievement of this re-imagined future. Written in 2002, the volume edited by Roth and Désautels (2002a) exemplifies this approach. They make use of the concept of 'Risk Society' (Beck, 1992), where the risks for living in our times are amplified by the scale at which scientific and technological ventures are undertaken, leading to unequal distribution of risk across populations. Exemplars of these situation include the industrial scale disasters of Chernobyl of Bhopal, or the horrific mutations caused by thalidomide. In each of these cases, what was ostensibly 'safe' and beneficial technology created by an élite coterie of scientists and technologists overlooked key factors that eventually led to tragedy. Roth and Désautels (2002b) argue that current science education efforts feeds individuals into such circumstances by offering a form of schooling that too closely resembles religious indoctrination:

> [...] it is relatively easy to show that science education is a sub-system of science. This sub-system, through a re-production cycle, which begins with kindergarten and goes through university-level education, produces teachers who, without malice, teach dogmas in a pattern that form more than one link with the teaching of religion. For instance, the nature of science as producing truth, as it is taught in most science classrooms, is equivalent to the dogma of the Immaculate Conception of the Catholic Church. Thus, scientific research is said to yield truth, whereas it is only by means of social influences that this truth can become tainted. More so, some researchers claim that one can interpret what goes on in school laboratories as a kind of ritualistic activity. (p. 5)

Because part of the issue with living in risk societies is that risk is unevenly distributed, with the people most endangered often the least informed and least politically able to evade the consequences of exposure to risk, a major role of science education is perceived by Roth and Désautels (ibid.) as the creation of a literate polis willing and able to study issues pertaining to local contexts

and skilled in scientific discourse and analysis. An exemplar of this idealized scientific literacy in action would be the case of the residents at the pseudonymous Saline Drive (Elmose & Roth, 2005). Faced with contaminated ground water supplies, a community petitioned their local government to extend the water mains to the suburban community. When government officials brought in 'experts' in a surreptitious attempt to deny the community's request for a costly project (and a prospective increase in property values), the locals were able to draw on their own resources to interrogate and problematize the expert findings of safe water quality, and authoritatively present their own findings instead. Introducing the concept of Allgemeinbildung, they write that:

> It has been argued that a basic requirement for making such choices and for teaching toward democratic citizenship is allgemeine Bildung or Allgemeinbildung, a term that can approximately be translated as general citizenry or general literacy. Allgemeinbildung involves competence for self-determination, constructive participation in society, and solidarity towards persons limited in the competence of self-determination and participation. (ibid., p. 21)

Further analyzing the term, Elmose and Roth (ibid.) explain that the sense of competence suggested consists of knowing that, knowing how, and knowing why. Without going into a detailed study of these terms here, they recommend for schools to adopt a problem-centred pedagogy that removes the a-priori, pre-determined curriculum with a set of student identified problems which must also facilitate student participation in search of, and implementing solutions.

Hodson's (2003) curriculum advocacy stems in large part from a concern about the state of the future given his assessment of extant conditions. In his assessment, a major influence in schools and societies is the excessive corporatization; slow creep of business discourse and rationalism; and the over-saturation of influence from the hyper-capitalistic project in all aspects of our lives, especially in North America:

> The pressures exerted by business and industry on schools to provide more 'job ready' people can be seen as part of an overt sociotechnical engineering practice in which new capitalism is creating 'new kinds of people by changing not just their overt viewpoints but their actual practices' (p. 651)

Hodson claims that the future we will find ourselves in will be characterized by "substantial and rapid change, and is likely to be more complex and uncertain than today's world" (p. 648), a conclusion he reaches by extrapolating from the "innocence and purity" (of science) in the 1970s to the current state where where science and technology have been shown to be "non-neutral, interested parties" by its allowing itself to become increasingly commercialized, industrialized and militarized. He proposes a way out of this current: inform, and then explicitly politicize students so that they may be able to act in ways which are beneficial to their own long-term interests:

> As indicated earlier, the curriculum proposals outlined here are unashamedly intended to produce activists: people who will fight for what is right, good and just; people who will work to re-fashion society along more socially-just lines; people who will work vigorously in the best interests of the biosphere. It is here that the curriculum deviates sharply from STS courses currently in use. The kind of scientific literacy under discussion here is inextricably linked with education for *political literacy* and with the ideology of education as social reconstruction. The kind of social reconstruction I envisage includes the confrontation and elimination of racism, sexism, classism, and other forms of discrimination, scapegoating and injustice; it includes a substantial shift away from unthinking and unlimited consumerism towards a more environmentally sustainable lifestyle that promotes the adoption of appropriate technology. (ibid., emphasis in original, p. 660)

In his framework, he conceives of four levels of sophistication, with the lowest level concerned with informing and convincing students of the socio-cultural investedness of scientific knowledge; up to the highest level where students prepare for and take action on a variety of issues relevant to their contexts. As for pedagogy, he proposes a mélange of informal learning context and experiential learning, especially to encourage ecological concern and a sense of 'connection' to the natural

environment. Of significance here is Hodson's insistence that 'political literacy' be an essential part of science education, and his admission of a sense of pessimism with regard to the rate at which these proposed changes may be made to schooling. For the former, and only to prefigure here a more extensive discussion in a later section, there are significant differences between the knowledge forms in the natural and human sciences, such that teachers and students may not be ready for a competent discussion of what it means to become 'politically literate'. Here, it is important to note that the differences in types of knowledge is presented with no intention of pursuing a demarcation-based argument (e.g. "political literacy is not science and therefore has no place in the science classroom").

To be sure, these curriculum and pedagogical proposals are certainly not new. Jenkins (2002) notes on the opening of his chapter that "attempts to link the the school science curriculum with social, political or economic concerns are as old as science education itself" (p. 17). Notable initiatives in his retelling of historical precedents include pre-World War II efforts to teach 'human biology' or 'social biology'; and UK-based efforts to encourage students to "think like scientists" or "behave like a scientist for a day". Eventually, approaches began to settle on to a generic 'STS'-like (Science-Technology-Society) method, although Pedretti and Nazir (2011) remind us here that there are multiple strands in pedagogical approach and curriculum emphasis in the movement. Jenkins (2002) claims that this arose, in no small part, due to the publication in 1962 of Rachel Carson's Silent Spring, which riveted the imaginations of an entire generation. Making distinctions between fundamental, strategic, and mandated approaches to institutionalized science, Jenkins (ibid.) makes the case for existence of a fourth form. Called 'citizen science', "science which relates in reflexive ways to the concerns, interests and activities of citizens as they go about their

everyday business" (ibid., p. 25), Jenkins proposes that the current lack of interest in science among students may be due to their perceived lack of connection with the abstract institutional forms that are conventionally taught in schools. Considering the 'unscientific' knowledge that are nonetheless helpful for people working in empirical contexts, Jenkins (ibid.) proposes instead that schools focus on 'practical reasoning', directed toward action that has immediate local influence.

With similar consequences for science education, Jenkins (2007) questions the construct of 'school science', which he claims to be one that is primarily concerned with a universal, abstractified 'scientific method' as a "uniform and stepwise exercise in logic" (ibid., p. 275). Important in Jenkin's (2002, 2007) approach toward curriculum advocacy is the underlying assessment of the nature of scientific knowledge and its role in schools and societies. While Roth and Hodson surveyed above also make implicit and explicit assertions about the nature of scientific knowledge, Jenkins is reviewed here in detail because he makes rather clear and specific claims. Firstly, he proposes that science and technology have intermingled to such an extent that there does not seem to be clear boundaries between them. Secondly, related to the first point, the traditional disciplinary silos of physics/chemistry/biology have become somewhat obsolete with the introduction of "GRAIN—genomics, robotics, artificial intelligence and nanotechnology" (ibid., p. 272). Thirdly, in contrast to some constructivist pedagogical approaches where students are encouraged to 're-invent' fundamental theories for themselves, Jenkins (ibid.) reminds us that science has "emerged in their modern form so late in human history", only because "the sciences require thinking about the natural world in ways that are often far from obvious" (p. 276).

Representative of another strand identified in the literature, a concern with the microscopic effects of science curriculum and pedagogy has researchers coming to similar conclusions about

how and what to teach. Targeting traditionally underserved populations, the goal of researchers like Barton and Osborne (2002); Tan and Barton (2010); Roth and Barton (2004); and, Tobin and colloborators (2002; 2005) has been to re-examine the role of science education in the lives of the marginalized, often minority and racialized subpopulations of dense urban centres. A common narrative trajectory of these research approaches resembles that of famous cinematic productions like Dangerous Minds: (i) An heroic character enters a classroom context filled with recalcitrant students who have been hardened through their prior interactions with schooling; (ii) hero attempts to teach science, only to find that conventional approaches do not work; (iii) a radically different pedagogy is attempted, to much success. From a research perspective however, these cases have much to demonstrate. For example, Roth and Barton (2004) open their book with a rather gloomy summary of the status of societies and the contribution of (school) science in making creating the current conditions. They then make clear their stance regarding the role of knowledge in societies:

> Scientists can hunt quarks, figure out the genome, or construct new macromolecules because they are, like all the construction workers, cleaners, repairpersons, computer programmers, and so on, a constitutive part of society [...] It becomes clear, then, that it is not individual knowledge and skill that is important, but knowledge and skill that are available to human endeavours at a collective level. If we accept that there are many things that scientists do not know or need to know, we should also accept that others—baker, construction worker, farmer—do not need to know that a neutron has a mass nearly identical to protons, or what neutrons or protons are in the first place. If we accept that most scientists do not know that their lawn mower has stopped working because the carburetor is clogged or how to take it out and clean the carburetor, why then do we expect all to know that a living cell is composed of a small number of elements mainly carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur? (p. 11)[1]

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1. Although, the answer to that last question could be that these knowledge aims are intended for grade 9 to 12 science students (these expectations were extracted from the AAAS Benchmarks), who could be fairly expected to know about these ideas in preparation for later education or a career that would require this knowledge.

Roth and Barton take their concept of collective versus individual knowledge to consider case studies in the challenging context of inner-city homeless shelter in an impoverished New York City neighbourhood. Letting the shelter youth decide what they wanted to work on, they eventually worked on a urban rehabilitation project, cleaning up a lot that was "abandoned and full of litter, including ripped open garbage bags, feces, broken bottles, and crack vials" (Roth & Barton, 2004, p. 87). Through a process where the students learn science through its use in genuine contexts, the youth learnt about planning and implementing an inquiry, and other knowledge associated with tending, growing and selling produce to a local community.

To summarize this section then, I have been concerned here with motivations and purported goals of researchers with regard to science education. Among the messages that may be discerned from this sampling of viewpoints reviewed here are: (i) an overwhelming concern for the state of the natural and/or social environment, usually accompanied with a negative assessment of the status quo or a prediction of disaster if conditions persist unmitigated; and (ii) a imperative that science education apply itself to the amelioration of these degraded and deteriorating conditions. There are a few trends in the foregoing discussion which would be worthy to highlight; I will list them below.

### 2.2.1     *Naïve possibilitarianism*

First and foremost, there is an underlying belief, bordering on faith, in the ability of schools to make positive changes in society. While it is hard to reject out of hand the underlying logic of such a position, there are significant reasons to adopt a more cautious and measured approach. In the first place, there are significant reasons enough to suspect that the entire institution of schooling can change sufficiently to accommodate the proposals suggested by researchers. The funda-

mental purpose, structure, and organization of schools have remained essentially unchanged since mass public schooling became a reality in many parts of the world. In addition, curriculum and pedagogical proposals are but one portion of the ecology of interests surrounding the school system, large though it may be. Also important are issues of assessment, policy, leadership, social environment and other factors which may undermine the effectiveness of any of these proposals. Larry Cuban, for example, expresses a negative opinion on the prospect for schools as a system to change beyond the the almost periodic sloganeering projects (Cuban, 1990; Cuban, 2003), with schooling remaining essentially unchanged. Notwithstanding these works, and concerned at this point only at description of current projects in curriculum and pedagogical advocacy, it is perhaps my place here to only point out that these proposals appear to fall into the category of what Geoff Whitty (1985) may have termed as naïve possibilitarianism. Whitty uses it to describe a specific practice of critical pedagogues, which ultimately places a faith in the ability of that pedagogical practice to "not only transform education but also lead to wide-ranging changes in wider society" (p.30). Borrowing this term, I would extend it to include the general faith that just mere changes in school curriculum and pedagogy can change society. After all, there are significant political forces and deeply entrenched segments of societies whose very existence is dependent on the status quo. This is not to be overly pessimistic to the point of cynicism, but to recognize that, the project that researchers propose represent no less than a radical, revolutionary changes to the entire social organization of contemporary societies, especially for those whose works appear in the Activism special issue at the beginning of this chapter.

### 2.2.2 *The nature of knowledge and its implications*

If the above may appear borderline frivolous, a far more serious issue has to do with the way in which these proposals treat the nature of knowledge. Researchers present knowledge, as Roy

Nash (2004) would express it, as essentially socially arbitraries, negotiated positions ultimately analyzable to reveal the thoroughgoing influence of power on all forms of knowledge. This position may be seen or inferred in positions like Hodson's, where he claims that "[a] fundamental principle underpinning this approach is that all curriculum knowledge should be regarded as problematic, and open to continuous and rigorous scrutiny, critical appraisal and revision" (Hodson, 2003, p. 666, emphasis added); or when Jenkins (2002) declares that "[t]he work of historians, philosophers, and sociologists of science has rendered "antique" the understanding of science that "explicitly or implicitly [has] provided coherence and security for generations of [science] teachers" (Ravetz, 1989, in Jenkins, 2002)". This position is also taken up by researchers who claim that school science should necessarily closely resemble science as practiced by scientists (e.g. Niaz, 2011), or that science is best taught through its use in localized contexts minimally removed from the learners' immediate field of experiences (Barton & Osborne, 2002; Roth, 2010; Roth & Désautels, 2002b). Importantly, and a point that I will take up more deeply later, one class of proposals take their warrant for modifying the school science curriculum based on developments in our understanding of the nature of knowledge. For example, Hodson (2003) claims:

> Recent scholarship in the history, philosophy and sociology of science has effected a major shift from the view that scientific knowledge is universal, coherent, objective and unproblematic towards recognition that it is sometimes uncertain, contentious and unable to provide clear, unambiguous answers to many important questions. There is increasing recognition among science educators that science is a product of its time and place, inextricably linked with its sociocultural and institutional location, and profoundly influenced by its methods of generation and validation. (p. 647, emphases added)

The key point of this critique, then, is Hodson's assertion of the sociality of knowledge, that there are implications to the curriculum and pedagogy of the curriculum of science that derive from recent studies in the sociology of knowledge.

The issue here is with the opposing pole of the arbitrary-necessary dichotomy; or, in the language of the recent work by Michael F. D. Young (Young, 2008a; Young, 2008b), whether there are knowledge forms which are epistemologically better, and not merely sociologically superior by association with powerful groups. In a deceptively straightforward sentence that captures the essence of the project in the sociology of curriculum in the last decade or so: Just because some knowledges are knowledges of the powerful, does not detract from the possibility that these knowledges are powerful, in and of themselves. The implications for curriculum researchers and other advocates should be clear—given that students should acquire powerful knowledges, what rational criteria are there for the in/ex-clusion of knowledge forms in the school curriculum? Of course, this is merely deferring the discussion of what it even means for knowledge to be powerful. For this chapter, interested mostly with a survey of current threads of research interest, I shall leave an extended discussion of these issues till later. For now, I will turn next to environmental education as it is a vital part of the context for my empirical study, and also because there are similarities between recent environmental and science education curriculum proposals.

## 3. Environmentalism and environmental advocacy in schools

As already reviewed above, one of the concerns that ostensibly motivates researchers toward curriculum theorizing derives from an analysis of the nature of the environment. This concern is evidently shared by officials in the Ontario Ministry of Education, among many other similar organs of state worldwide. This has resulted in the commission of a working group and their report to the Ministry (Bondar et al., 2007), followed by an acceptance of their recommendations (Ontario Ministry of Education, 2009), and subsequent changes to the science curriculum reflecting the importance of the environment (Ontario Ministry of Education, 2007; Ontario Ministry of

Education, 2008a; Ontario Ministry of Education, 2008b). While there is little controversy in the mainstream channels of discussion with regard to the status of the environment, what exactly needs to be done in schools is not entirely clear. For example, Lucie Sauvé (2005) surveyed the field of pedagogical strategies in environmental education, and found no less than fifteen distinct 'currents', each with its own strengths and limitations. In science classrooms, a likely pedagogical strategy would be the 'scientific current', with a focus on mutually reinforcing scientific and environmental understanding by emphasis on the rigorous analysis of environmental issues. Typically, environmental issues are used as a metaphorical 'hook' to stimulate interest in scientific ideas and also provides a "social and ethical dimension to scientific activity" (ibid., p. 17). Potential drawbacks to such an arrangement include a perceived threat to the traditional disciplinary boundaries and, on the other hand, a concern that an overly scientistic approach to the environment could impoverish the social, ethical and moral dimensions of environmental understanding.

While Sauvé's fifteen currents include some which are no longer in vogue, researchers in environmental education have largely come to the spontaneous agreement that place-based approaches offer significant prospects for school based pedagogical techniques (Greenwood, 2008; Gruenewald, 2003; McKenzie, 2008; Smith, 2007; Stevenson, 2008; Zandvliet & Fisher, 2007). Smith (2007) describes place based approaches as consisting of "Cultural journalism, expeditionary learning, problem-based learning, and contextual teaching and learning. Placed-based education is also frequently associated with service learning, civic education, and project-based learning" (p. 190), and explains that a contemporary interpretation of its theoretical foundations involve:

> Drawing upon Freire's advocacy of social and cultural analysis and the process of conscientização, the awakening of critical consciousness, Gruenewald argues that teachers who practice place-based education must work with their students to investigate assumptions that inhibit their ability to live in ways that support the welfare of everyone

and the health of local ecosystems. They must also learn to question and challenge perspectives that harm both their own lives and the lives of others through a process he refers to as 'decolonisation'. (p. 192)

In addition to conscientization and decolonization, Gruenewald (2003) offers that places need to be re-inhabited, a process by which steps are taken to "restore social and environmental practices that are both beneficent and sustainable over the long term" (Smith, 2007, p. 192).

In addition to lococentric approaches, a complementary strategy may be seen in the action competence approach forwarded by Jensen, Schnack and associates (Jensen, 2002; Jensen & Schnack, 1997; Jensen & Schnack, 2006; Mogensen & Schnack, 2010). Jensen and Schnack (1997) realized that much of environmental education had been (and still is) concerned with informing students of the latest "tragedy, malfeasance, and ignorance" (Gruenewald, 2008) to strike the natural environment, perpetrated by destructive human beings. In effect, the result of such environmental education was the creation of a heightened state of anxiety, over which, for the most part, students are rendered powerless as there is no accompanying overt instruction directed toward the resolution of the root causes of environmental issues. It is interesting to note that in this framework, Jensen and Schnack would not consider activities conventionally encouraged in schools (e.g. recycling, reducing power consumption) to be sufficient; they claim that the "relevant answers to environmental problems are not only a matter of quantitative changes (less consumption of resources, less transport by car, less electricity consumption, etc.), but also (and maybe more so) of qualitative changes" (ibid., p. 472). Jensen and Schnack base their argument on two key premises, worth quoting at length:

> First, it is not and cannot be the task of the school to solve the political problems of society. Its task is not to improve the world with the help of the pupils' activities. These activities must be evaluated on the basis of their educational value and thus according to educational criteria. A school does not become 'green' by conserving en-

ergy, collecting batteries or sorting waste. The crucial factor must be what the students learn from participating in such activities, or from deciding something else. Second, concerns about the environment, health and peace must be coupled with a corresponding concern for democracy. Education for democracy, or political liberal education, is, in itself, a fundamental educational task. We do not believe in educational efforts in relation to the environment, health and peace which are divorced from this fundamental perspective. (p. 473, emphases added)

In their framework, a major goal of action should be directed toward sociopolitical change, as there is a firm belief that environmental issues are firmly rooted in unquestioned social practices. Further, they reason that in typical school contexts, a confluence of (i) scientism; (ii) pedagogy directed at moralizing and behaviour modification; (iii) overly academic orientation (as compared to the practical); and (iv) unrealistic simulations and role play, mean that conventional environmental approaches are unlikely to attain any significant measure of useful change in the status quo.

In attempting change of the status quo, Stevenson's (2007) insights have been recognized as providing a crucial framework to think about the contradictions schooling poses to effective environmental education. In recounting the relationship between environmental education and democracy, Stevenson supported the assertion that the aim of schooling is to further the democratic imperative and to offer students choices unto their own destinies. As a consequence, students' need exposure to different perspectives to ensure rational, defensible decision making, and a competence in socio-political organization in order to effect their choices. This latter competence is especially important and absent in much of conventional schooling; Stevenson argues that a genuine undertaking needs to cultivate these competences as it would be insufficient to offer choices but no real way to act on it. However, Stevenson noticed four areas of contradiction; (i) in terms of philosophical intent, schools have had a stable structure almost globally for over two centuries as the primary agent of social reproduction, whereas environmental education demands a (politically)

revolutionary approach; (ii) the classroom pedagogy of schools is biased toward individualistic, lecture-styled approaches of synthetic material, while what is required is a focus on co-operative, real-world problem solving of current situations; (iii) school organization is biased toward mass credentialling and the efficient processing of students, which is anathema to problematic inquiry, ambiguity, contradictory stances and associated psychological unease; and (iv) curriculum ideologies, where the high status, 'public' knowledge being taught in schools is at odds with the 'private' knowledges like aesthetic appreciation and other intangible emotional connections to nature. As a measure of the importance and durability of the 'gap' identified by Stevenson, it is of note that the editors of Environmental Education Research chose his work to be reprinted; in its original form, it was published as a book chapter in 1987. These contradictions have since been dubbed as 'Stevenson's Gap', and judging by the systemic nature of these contradictions, it is likely that barring radical change, the gap will persist for a long time to come, as contemporary research still shows (e.g. Barrett, 2007; Hacking, Scott, & Barratt, 2007).

To close this section, I want to note from this very brief review of environmental education that there appears to be some similarities in concern between researchers in science and environmental education. In both, there is an overriding pessimistic diagnosis of our social reality: for science educators, a predominantly class-based analysis pointing towards mainstream science in the service of oppressive regimes; and for environmental educators, our very existence threatened by ultimately murderous actions. From here, a restatement of faith in schooling to develop in our children positive attributes and ways of thought that may eventually lead toward amelioration of the perceived social disaster. These take the form of exhortations that schooling should prepare students to be more effective participants of democracies, by giving them opportunities to practice

taking active roles in the determination of their own destinies. The immediate question that emerges from such a review include, at one extreme, the possibly dubious ethical position of getting children to solve the political problems of society; to the more prosaic and pragmatic of whether such modifications to curriculum and pedagogy are actually able to achieve changes in society. While the former is a serious philosophical question that demands a fuller deliberation than I have space here[2], and the latter is rightly the domain of an empirical undertaking, there are questions that I believe require formal theoretical consideration.

Specifically, if we wish to account for the radical social potential of curriculum proposals, we should have the means of understanding the relation between society and the school curriculum. To this end, certain enduring problematics have been raised by scholars in the sociology of curriculum: (i) What is the connection between the microscopic contexts of schooling and the macroscopic/molar phenomena of society? (ii) What does power do in school? (iii) How does power do what it does in school? (iv) What influence would a sufficiently developed theory of (school) knowledge bring to sociological recommendations to the curriculum? While these questions are not the central research questions of the empirical study that will be reported on, they are nonetheless important as they inform the theoretical framework of my study. In attempting to obtain more clarity on these questions and related issues, I next turn to researchers who have studied these questions relating schools and society, in the following section.

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2.  and to which I am simply inclined to respond in the negative

## 4.      Precedents in the sociology of curriculum

Earlier, I wrote about the role of knowledge in the school curriculum, specifically referring to recent work in the sociology of curriculum. To be sure, the status of knowledge and its role in the school curriculum have seen dramatic shifts in thought in the last forty years. Because some of the proposals in science education may be seen as outgrowths of projects in the sociology of curriculum, it is worthwhile here to survey the range of positions taken over this issue, to get a sense of what has been discussed, and the state of our understanding. Although any demarcation of periods in history is always arbitrary, there are good reasons to start this historical recounting from around the 1970s, if only because one of the key figures of the movement has taken up almost diametrically opposing positions as to bookend the boundaries of the argument. In any case, this period is chosen to show the almost full range of positions on the role of knowledge in curriculum, taken by scholars dealing with epistemological and sociological issues of school knowledge.

According to prominent observers (Ladwig, 1996; Whitty, 1985), the field of study concerned with the sociology of curriculum came into its own in the 1970s, with the publication of Michael F. D. Young's edited book Knowledge and control: New directions for the sociology of curriculum (Young, 1971). That is not to say that similar enterprises did not exist before this time, but that the set of concerns and the general project that is now uniquely identified as the sociology of curriculum is most strongly identified with the outgrowth from this work. Prior to Young's book, a major concern with the sociology of education, at least in the United Kingdom, had been with the underachievement of working class youth:

> British sociologists in the twenty years after the Second World War were largely concerned with the problem of increasing access to schooling rather than with examining the nature of the education which they sought to distribute more widely. Their interest focused upon the consistent tendency for the children of manual workers to receive less schooling and achieve less success at each of the successive educational hurdles than the children of professional and managerial workers. (Whitty, 1985, p. 9)

Efforts were directed toward studies which explored institutional changes aimed at student retention in school and corrective actions for students, based on the notion that schooling was an unmitigated good, and that a longer exposure to the schooling system allowed for student success and greater upward social mobility. The foundational concern has been with the relationship between social class and educational performance. As soon as organizational innovations showed little by way of changing the correlation between social class and educational performance, attention began to shift toward the (mis)match between home environments and school culture. It was Young and his colleagues who then turned the spotlight onto questions of the curriculum. In particular, the project of the sociology of curriculum began to treat knowledges as problematic and as an object of inquiry, instead of as a given. This theoretical position had consequences for education, and specifically, the curriculum, as:

> the worthwhileness of particular educational activities can no longer be justified in absolute terms once the social basis of such justification is recognized. The apparent self-evident justification for education into particular forms of knowledge is laid bare as an ideological statement. The process through which particular curricula are institutionalized and justified becomes open to sociological examination. (Gorbutt, 1972, in Whitty, 1985, p. 14)

That the school curriculum is essentially non-neutral and favoured the privileged arises ultimately from the epistemological position that knowledge is socially constructed and the privileging of certain knowledges in schools is an arbitrary decision. To be sure, however, Whitty's (1985) opinion on the matter is that this epistemological relativization was not the consequence of a hard

won theoretical struggle against philosophers, but to be utilized as a "useful procedural device for subverting our taken-for-granted assumptions about the seemingly absolute status of the knowledge which has come to be institutionalized in the school curriculum" (ibid., p. 15). In clearer terms, Whitty notes that Young founded the new sociology of curriculum by:

> rejecting the assumption of any superiority of educational or 'academic' knowledge over the everyday commonsense knowledge available to people as being in the world. There is no doubt that teachers' practices—lecturing, syllabus construction, examining, writing textbooks, etc.—are predicated on just the assumption of the superiority of academic knowledge that is being called into question. (Young, 1973, in Whitty, 1985, p. 15)

In short, a recognition that schools were guilty of an "unjustifiable cultural bias" (Whitty, 1985, p. 17). A major concern became the communication to teachers of the significance of their daily actions and everyday activities, accompanied by a sense of what Whitty termed naïve possibilitarianism: that "questioning teachers' taken-for-granted assumptions about prevailing curricular arrangements and pedagogical practices, would not only transform education but also lead to wide-ranging changes in wider society" (ibid., p.30).

It is perhaps important here to remember that Whitty's work has been around for more than 25 years; this is not merely to say that science educators may not have had the benefit of theoretical perspectives specifically dedicated to reducing the disparity between the privileged and marginalized. There is also the point to be made that there are enduring problematics which evade easy solutions, and that the complexities of trying to change society through curriculum modification are certainly not trivial. For example, an early concern has been with the concept of correspondence, strongly associated with the work of Bowles and Gintis (Bowles & Gintis, 1976; Cole, 1988), which showed that school life, administration procedures, and routines were organized to produce

"a workforce that would fit into and accept as legitimate the patterns of inequality required by the capitalist system of production" (Whitty, 1985, p.25).

A competing framework came in the form of the resistance hypothesis, following the publication of the seminal volume by Paul Willis in 1977 (Dolby & Dimitriadis, 2004; McGrew, 2011; Willis, 1977). Based on an ethnographic study of a group of working class 'lads' in the British public school system, Willis showed how these young men developed their own brand of counter-cultural practices based loosely on working class shop floor behaviours, to resist their own marginalization and the schools' production of a docile working class. The principle of correspondence was also criticized for its overly structural analysis, and for lacking a explicatory mechanism capable of describing classroom level processes. This space was quickly taken up by Bourdieu's theory of social reproduction (Bourdieu & Passeron, 1977). As summarized by Ladwig (1996), two major arguments formed the thrust of the reproduction thesis: (i) schools were sites of reconversion, that is, for specific fractions of the middle class, a major function of schools was to serve as locations where cultural capital could be exchanged for academic credentials and future access to privileged positions; (ii) schooling was responsible for legitimating the 'meritocratic' ideology: "By working as a cultural market, education not only legitimated the reproduction of social inequalities in which it was implicated, it also legitimated itself; or, as Bourdieu and Passeron put it, 'legitimation of the established order by the School presupposes social recognition of the legitimacy of the School'.

Another work that deserves attention in this admittedly brief overview would be Henry Giroux's Theory and Resistance in Education (Giroux, 1983). Based on the contention that conventional sociological approaches up to its time was narrowly focussed on description and theorizing, Giroux took the bold step of proposing instead his framework for what he termed critical ped-

agogy. Based largely on the neo-Marxist theories of the Frankfurt School (e.g., Marcuse, 1991), Giroux developed pedagogical recommendations that were specifically designed toward a goal of radical sociopolitical change. Key planks in his argument include: (i) a rejection of the influence of positivism in the social sciences; (ii) a dissatisfaction with structuralist theories for their inherent pessimism in the inevitability of reproduction of social injustices; as in, for example, Bourdieu's explanations of the role of habitus and social reproduction (Bourdieu, 1977; Bourdieu & Passeron, 1977); and (iii) an acute awareness of the 'hidden curriculum' of schooling in its roles of disciplining students and normalizing oppressive social relations; and perhaps most importantly (iv) a firm belief in valuing theories only in their utility in filling the gap between 'what is' and 'what should be'.

As a movement deserving of a category in itself, feminist approaches to education offered unique insights to the role of knowledge in education. Ultimately however, the epistemological approach of these arguments operate on similar grounds as the other movements at the same time, as I will elaborate in the next chapter. Tracing its roots as far back as 1792, with the publication of A Vindication of the Rights of Women by Mary Wollstonecraft (Dillabough & Arnot, 2001) asserting the intrinsic equality between the sexes in terms of reasoning abilities and hence, forms of schooling, contemporary feminism is now recognized as fundamentally predicated upon the idea that gender is a social category, and hence, a social construction (ibid., p. 31). The primary research agenda for feminist scholars has been the uncovering of gender patterns of schooling and its relation to broader social inequalities, but this was soon criticized as being too simplistic and for "failing to capture the the range of different and conflicting approaches or to improve women's social positioning more generally" (ibid., p. 32). The postwar feminist agenda soon expanded in re-

sponse to a realization that conventional feminist thought was entrenched in white, middle-class values, and was not capable of capturing the full range of oppressions afforded by theories which took into account class and ethnicity (Dillabough & Arnot, 2001; Sandoval, 2000). There is now a full range of feminisms, all of which take into account the unique lived experiences of women across different contexts. Typical of this approach is perhaps what may be termed 'maternal feminism', strongly associated with the work of Madeleine Grumet (1988). Her concern has been with understanding feminine oppression through the questioning of the normal, natural order:

> The project of this text is to draw that (bodily) knowledge of women's experience of reproduction and nurturance into the epistemological systems and curricular forms that constitute the discourse and practice of public education. It is an argument drawn from the experience in my own life that is most personal and at the same time most general as it links me to those who share my sex and gender and those who also acknowledge reproductive responsibility for the species. (Grumet, 1988, pp. 3-4, in Ladwig, 1996, p. 64)

Key to the feminist approach, especially in concert with the poststructuralist movement, was the deprivileging of the 'grand narrative' and 'voiceless' propositions, favouring instead an analysis that focussed attention on positionality and standpoints, based ultimately on the notion that "gender was a social category, [and] hence a social construction" (Dillabough & Arnot, 2001, p. 31).

This historical retrospective is introduced here for two main reasons: firstly, this brief review is meant to serve as an indication of the state of sophistication of sociological arguments in science education. Although I have yet to make the case at this point, I think it is not a stretch even at the outset to claim that sociologically motivated curriculum proposals in science education could do with a certain amount of refinement. For starters, besides naïve possibilitarianism, there appears in many of the science educators' writings, hints of an "unwarranted tendency in some of the writings to assume that there is a pre-constituted audience of vaguely socialist teachers who share the au-

thors' political orientations which therefore do not need spelling out in more detail" (Whitty, 1985, p. 52). To be sure, the intention here is not to disparage the work of researchers attempting to link the curriculum to social issues; the point I would make however, is that attempts to change society need to consider many factors, some of which perhaps may possibly be counter-intuitive.

## 5.    Radical sociology and the margins

As suggested at the beginning of this chapter, there are reasons to suggest that some of argumentative bases and rhetorical strategies in the sociology of curriculum could have contributed to its location in the margins. This marginal position is noticed when we consider how little of contemporary mainstream education has been influenced by the radical proposals. For all the research in the hidden curriculum, for example, most teacher educators would be hard pressed to name specific curriculum or pedagogical interventions aimed at attenuating the effects in daily classroom practice. For that matter, given that contemporary researchers in science and environmental education are able to declaim passionately about the inequities extant in schooling and society, the conclusions that may be drawn are that either social change proceeds at a glacial pace, or that insights in the sociology of curriculum are somewhat irrelevant to change in society. While there are good reasons to suspect that former, James Ladwig (1996) made a convincing case that at least for some strands of research in the (so-called) radical sociology of school knowledge, whose work is surveyed above, the research and rhetorical strategies used by these scholars have contributed to its own self-marginalization and irrelevance to all but those who are already committed to the particular worldview espoused by these theories. While efforts like the Science-Technology-Societies-Education (STSE) movement (Pedretti & Nazir, 2011) exist within the domain of mainstream science education, its recommendations and conclusions are likely less radical than some of these sociologically

motivated curriculum proposals, and its practical implementations limited by such mechanisms as the Stevenson's gap. Still, it is useful here to repeat Ladwig's arguments, if only to make sure that the more radical curriculum proposals in science are made more effective.

Ladwig begins his argument by recounting the developments in the sociology of curriculum from around the 1970s, as mentioned above. A major line of argument for Ladwig derives from the nature of scientific argument; specifically, a point that he was trying to make with regard to the radical sociological perspective was that much of the evidence used to construct their case, the methods used, and the conclusions arrived at, were simply unscientific. For instance, he noted that in Anyon's (1980) study of the hidden curriculum, the data collected from the ethnographic method used could have equally well been made to support an alternative conclusion; the choice of theoretical framework to analyse the data was not innocent, and revealed a bias toward structural, economic class category analyses despite the claims of recognizing resistance and agency. Further analyzed by other researchers, Anyon's data was developed into theories which featured what Ladwig termed as "fail-safe theories":

> Consider, as one example, the reproduction versus resistance couplet. Interpretation through such a lens would undoubtedly always find empirical verification. If something wasn't seen as reproductive, it could easily have been labeled resistance. Or, as another example, if school practices didn't clearly meet the needs of capital, they could be interpreted as a result of democratic struggles within the State. Speaking in terms of "contradictions" may have provided more subtlety to the U.S. New Sociology's theory; but it also provided a theory which could never be wrong. (Ladwig, 1996, p. 40, emphases added)

In radical sociologists' choice of theoretical lens, Ladwig noted that the economistic, structural Marxist position was given primacy, and when there was a realization that segments of the population were being ignored and/or offended, Popperian ad-hoc hypotheses were extended to include gender/sexual orientation/religions/linguistic dialect/etc; there had been no systematic explana-

tion for the choice of analytical framework, including the structural Marxist chosen as the dominant framework.

Another trend that Ladwig noticed was the reliance of radical sociologists on appropriating qualitative data obtained by other researchers. Besides the point that such reliance on qualitative date leaves out quantitative analyses which could be better suited to the task of explaining constructing arguments about the growing inequalities in society, there remains the issue of applying alternative research frameworks onto data not explicitly collected for one's purposes:

> Anyone who has ever tried to carry out secondary analysis of material collected in relation to another problematic, however neutral-seeming, knows that even the richest of data can never fully and adequately answer questions for which, and by which, they were not constructed. It is not a question of challenging on principle the validity of using second-hand material, but rather of recalling the epistemological conditions of this work of retranslation, which always deals with (well or badly) constructed facts and not with data. (Bourdieu, Chamboredon, and Passeron, 1968/1991, in Ladwig, p. 130)

In avoiding quantitative research methods, radical sociologists marginalize themselves from mainstream educational research communities, for whom an agnostic flexibility of choice of appropriate methods directed toward the resolution of problems contrasts with the "persistent intellectual disposition among radical educational researchers which pushes away quantitative empirical work" (Ladwig, 1996, p. 131).

The most significant idea from Ladwig's work which I want to use in this project is his analysis of the radical sociologists' tendency toward a false characterization of traditional social science/ educational research as positivistic, and their accompanying rejection of positivistic science and its corollaries:

> 1) that empirical/analytical knowledge and science serve the interest of control, thereby making positivistic science oppressive; 2) that a socially subordinate perspective holds "epistemic privilege"; and 3) that the incommensurability argument means critic-

al social science would not be understood by those in the positivistic "paradigm." (Ladwig, 1996, p. 108)

While these perspectives are related, Ladwig believes that at the root of all these conceptions, one would find the notion that knowledge is a social construct, a position whose recent (philosophically speaking) reformulation he ascribes to Berger and Luckmann (1966). Within this conception, traditional educational research was deemed to rely on epistemological grounds of 'objectivity' based on knowledge claims mirroring reality with perfect fidelity; in addition knowledge and fact were held to be distinct from beliefs and value. This form of positivism in educational research was criticized because it:

> 1) ignored the ostensibly fundamental distinction separating human sciences from physical sciences; 2) sought to emulate the prediction and control characteristic of the physical sciences within social analyses; 3) employed a methodological individualism which translated its epistemological assumptions into psychologized social phenomena (and endless checklists of mindlessly minute observable behaviors); and (thereby) 4) mistakenly assumed socially created characteristics to be inherent in individual people. In all, traditional educational research, which was taken to have followed this culture of Positivism, was seen clearly to be supporting the status quo. (Ladwig, 1996, p. 106)

Ladwig dispatched these perspectives expeditiously: with respect to the claims of positivistic science being oppressive, he reminds us that at the level of verifying hypothesis or propositions, social science can hardly be anything but value neutral. As for science in general, one only need to consider the liberatory role it played in medieval times to reconsider the notion of oppression. Considering epistemic privilege to be reliant on the notion of social constructedness of knowledge and an accompanying relativistic approach to truth claims, Ladwig simply points out that "relativist ideas are seen as self-refuting because some sort of a nonrelative claim seems to have been made the instant relativity was proclaimed" (p. 124). With a similar candour, Ladwig takes down the claim of incom-

mensurability by noting that whenever two claims are demonstrated to be incommensurable, one is actually making a translation.

To be sure, Ladwig argues that as matters of sociological arguments, these charges do hold: science in use by corporate entities in trenchant capitalistic societies does contribute to oppression; epistemic privilege is quite plausible in certain contexts; and incommensurability allowable when one considers an historical analysis of knowledge in sociology. While this may appear to be rhetorical waffling, Ladwig asserts that there are actually two distinct levels at which arguments are being made, one at the philosophical rhetoric level of demonstration, and the other being the social scientific rhetoric of evidence. This distinction is important as ultimately, Ladwig's project is not so much the refutation of these sociological perspectives in curriculum theory, but a concern over how the intellectual gains from work in these radical perspectives are not being applied to a sufficiently mainstream audience. Coming back to his analysis, he advances the idea that the difference between the philosophical rhetoric of demonstration and the scientific rhetoric of evidence lies in the manner in which each deals with rhetorical authority. He likens philosophical demonstration to the process employed by clergy speaking to the masses about the 'world outside':

> Presenting "the vision" held of the outside world (through allegory, reason, and appeal to supposedly shared subjective experiences), this intellectual for the masses attempts to persuade his audience that His is the real Truth. As my label suggests, this rhetoric relies heavily on philosophical, a priori, analytical demonstration. External references are made, but the basis of persuasion lies in the eloquence of the presentation—in the artistic, poetic construction of reality. (p. 147)

Whereas for the scientific evidence mode, he constructs the analogy of the secular courtroom:

> Here persuasion does not wholly rely on demonstration. Here an appeal must be made to evidence. Here the model is not of a sermon, nor even a dialogue between two parties. A mutually accepted (socially constructed) view of evidence, acting as a third party arbiter, is the result of a process of triangulated communication. Questions left

unresolved in the abyss of incommensurate knowledge claims can be mutually opened
to possibilities of empirical matters. (p. 148)

To Ladwig, the point of this extended analogy was to propose that the different modes constructed authority differently; whereas in the philosophic mode authority lies with the author, in the scientific mode authority is dispersed, and located within the diverse sources of evidence required to make the case.

Back to the charge of positivism which the radical sociologists lay on the mainstream educational research venture then, Ladwig infers that while it would appear that radical sociologists attempted to make (social) scientific empirical claims about their work, they were, essentially, making use of philosophical rhetorical strategies. It did not help that much of the "appeals to socially recognizable 'evidence' [were] rather limited" (p. 148). While Ladwig's criticisms of the radical sociological project are quite involved, I want here to draw out elements of his argument which will be useful to my own discussion. Here, I want to make use of this extended discussion to introduce a theme that seems to have emerged from the sociological literature in the last decade. Ladwig, being one of the first to articulate this idea, gives us the timely reminder of Marx's dictum, that "humans make their own history but the history upon which they build is not of their own making", and in a passage worth quoting at length here:

> Truth is the stake in a series of struggles of every field. The scientific field ... has this peculiarity: you have a chance of success in it only if you conform to the immanent laws of the field, that is, if you recognize truth practically as a value and respect the methodological principles and canons defining rationality at the moment under consideration, at the same time 'as bringing into battle in the competitive struggles all the specific instruments that have been accumulated in the course of prior struggles. The scientific field is a game in which you have to arm yourself with reason in order to win. (Bourdieu, 1990, p. 32, in Ladwig, 1996, p. 142)

In summary, the points I want to take out of this extended review of Ladwig's work are that: (i) while the sociological critique of the curriculum is fundamentally well intentioned, there are significant reasons to remain skeptical of some of its assertions especially those that are poorly supported by empirical findings; and, related and more significantly: (ii) there are social structures and established means of deriving socially acceptable truths in investigations that we cannot dismiss outright; or with a rhetorical flourish of 'incommensurability'.

## 6.      Voice, position, and epistemic privilege

A major contention of my thesis is that some of the socially motivated and radical curriculum proposals in science and environmental education could do with an increased measure of sociological sophistication. Besides a clearer picture of if and how curriculum changes can and do change society, there are recent threads in sociological discussions which do not seem to have been acknowledged by science and environmental educators. Specifically, in a line of argument similar to that used by Ladwig introduced in the previous chapter, there appears to be significant reasons to be wary of the 'discourse of voice', a term used by Moore and Muller (1999) in their analysis of contemporary sociological arguments. Moore and Muller explain that these approaches:

> adopt, or at least favour or imply, a form of perspectivism which sees knowledge and truth claims as being relative to a culture, form of life or standpoint and, therefore, ultimately representing a particular perspective and social interest rather than independent, universalistic criteria. They complete this reduction by translating knowledge claims into statements about knowers. Knowledge is dissolved into knowing and priority is given to experience as specialized by category membership and identity. (Maton, 1998) (Moore & Muller, 1999, p. 190)

Moore and Muller go on to explain why such a perspective may not be the best means of pursuing a socially progressive agenda. Most significant for them is the way in which these approaches detach progressive causes from "epistemologically powerful knowledge structures and from their pro-

cedures for generating and promoting truths of fact and value", and that "the anti-epistemological thesis undermine[s] the possibilities of producing precisely the kind of knowledge required to support the moral/political objectives" (p. 191). They also identify, as with Ladwig (1996), a penchant for such researchers to rely on small scale, qualitative and ethnographic type studies and "'culturalist' concerns with discursive positionings and identity" (Moore & Muller, 1999, p. 191), when precisely what is needed are large scale studies in mainstream contexts examining whether such changes actually help those that the changes are ostensibly meant to help.

Examining the epistemological bases for the mechanism of the voice discourse, Moore and Muller argue that despite its lack of intellectual credibility, this mechanism has surfaced repeatedly in several forms, suggesting that a sociological examination would be more productive. In their assessment, these repeated recurrences of the mechanism of voice since the 1970s indicate instead that: (i) despite the repeated refutations of voice discourse as a form of perspectivism, allegiance to this perspective probably reveals the relative insulation (and marginalization) of the field from the mainstream educational research discourse; (ii) an almost wilful neglect of 30 years of debate in post-empiricist philosophy of science reveals the use of voice discourse as a positioning strategy rather than a legitimate intellectual position; and (iii) evidence for use of the mechanism of voice as a positioning strategy can be seen in its invocation under several guises (e.g. New Sociological, Foucaultian post-structuralism, Derridan postmodernism) even though some of these theories may even be antithetical.

The voice device may be seen to present a rather seductive logic that makes it especially attractive to radical sociologists attempting to ameliorate social conditions:

> the device can be seen as transforming the 'cold' world of secular rationalism in which knowledge is divorced from knowers (what Popper (1983) called 'epistemology without

a knowing subject'), back into a 'warm' world of human characters. Whereas critical rationalism as an historically radical force systematically attempted to separate knower claims from knowledge claims (things are not true simply because the Chief, the Party or the Pope says so), this device sets out, once more, to privilege the knower, or the knower's imputed membership category, as the truth criterion. Perversely, post-modernism pursues a 'pre-modern' strategy of attempting to reinstate 'who knows' as the authority for 'what is known'. The fact that it celebrates the virtue of the oppressed against the calumny of the oppressor does not change the principle. (Moore & Muller, 1999, p. 193)

Use of the voice discourse generally proceeds by invoking solidarity with a position identified as subordinate, and then using that standpoint to construct a critique of the knowledge form perceived as central to the act of subordination. Therefore, in science, an expression like 'white masculine science' marks a fairly typical application of the mechanism of voice, and in Moore and Muller's opinion, represents a rhetorical strategy that has confused social/moral virtue with epistemic virtue. For example, while inclusion may be a morally defensible social virtue, 'inclusiveness' is not an inherent epistemic virtue: "first, because there is no necessary relationship between inclusiveness and truth or exclusiveness and falsehood; and second, because epistemological inclusiveness ('anything goes') removes any effective basis for arguing for social inclusiveness because all arguments, including those against inclusion, are equally valid—dependent on the perspective of the belief holders" (p. 195).

Another principle which postmodernists and other users of the voice discourse mechanism may be found to be guilty of is the epistemological principle of "all-or-nothing". Moore and Muller describe this principle as the mistaken notion held by some postmodernists: that since indeterminacy has been shown to be a vital property of all social practices, and that since science is also a social practice, there is no "formal demarcation criteria between kinds of practices and discourses"

(p. 198). The problem has been succinctly framed by James Bohman (1991, in Moore & Muller, 1999):

> "Even if interpretation is unavoidably indeterminate, it follows only that there is no unique best interpretation, not that there is no way to distinguish better from worse interpretations" (p.10; emphases by Moore and Muller). It is just such an 'all or nothing' argument that post-empiricist epistemology and philosophy of science has abandoned and, furthermore, did so from within its own tradition and within its mainstream critical discourse. (Moore and Muller, 1999, p. 198)

In sum, the problems that Moore and Muller identified with the mechanism of voice discourse are centred around its primary use as a debunking strategy: it represents the dominant discourse as positivistic and absolutist, even though no-one ever presses epistemic privilege by these means; it misrepresents the mainstream position of the epistemology of science with a straw-man version of positivism; and by its deliberate avoidance of insights in the nature of science, the only reasonable conclusion is that these fields that continue to use it are strongly insulated in their support of this particular position taking strategy.

## 7.  Conclusion

In a small way, we have strayed into a discussion of the nature of truth and knowledge, and the influence of power in social deliberations concerning truth and knowledge, as a suitably deep study of curriculum should entail. To summarize, I wanted to show that a current trend in the scientific and environmental research conversations was a concern with an assessed dismal social and natural environment. In many of these works, researchers assign a strong sense of responsibility to schools in ameliorative and restorative attempts, via proposals made to change curriculum and pedagogy. I then surveyed some of the historical developments in the sociology of curriculum, in order to show that sociologically minded curriculum theorizing has a fairly well established research tradition of its own despite appearance in its current form only around the 1970s. I wanted

to draw out the point that contemporary concerns in science and environmental education are not without precedent, and more significantly, that there are lessons to be learnt from the missteps of some of the radical sociologists. Prime among these is the mistaken notion of epistemological independence from established canons of truth-seeking and the over-extension into relativism of the principle of social constructedness of knowledge.

In the coming chapter, I will continue this discussion into the nature of knowledge, before returning once again to curriculum proposals in science and environmental education to frame my empirical study. To prefigure the discussion, I intend to discuss what has been dubbed the 'discourse of voice', a rhetorical strategy often used in conjunction with an implicit declaration of epistemic privilege in discussions of power and knowledge. Briefly, if epistemic privilege can be claimed on behalf of certain dominated groups, then some truths are more true than others. Ultimately, discussions about knowledge decay into discussions of power and resisting the vested interests of dominant groups; what is said matters less than who says it. Also to be discussed in the next chapter will be the nature of powerful knowledges—what does it even mean to say that forms of knowledge are superior to others; the role of sociality in knowledge—how should we interpret the social constructedness of knowledge; and the role of power in school knowledge—what does power do, and how does it do it?

# Chapter 3
# Theoretical framework

In the last chapter, I surveyed the work of sociologists of curriculum, ending off with a contemporary critique of the effectiveness of radical perspectives. Recall that these critiques were based on radical sociologists taking up a disparaging perspective of what was deemed positivistic scientific perspectives in sociological research, which resulted in corollary arguments that science was positivistic, that the voices of the oppressed possessed epistemic privilege, and that there were incommensurate paradigms between radical perspectives in sociology and mainstream educational research which prohibited translation and mutual understanding. In this chapter, I begin by continuing the analysis, focussing on the issue of epistemic privilege associated with the idea of social constructedness of knowledge. I will follow up with a review of Michael Young's recent work, which has become a significant updating and revision of his original position to now consider more critically the role of structures in knowledge and the distinction between school and non-school knowledges.

A major role for this chapter is in the introduction of the philosophy of (critical/scientific) social realism as a guiding principle for a theory of knowledge. In brief, while positivists and social constructionists hold polar positions on the nature of truth and knowledge, social realism take the middle path, acknowledging sociality as a means toward strong objectivity, while rejecting the constructionist/postmodernist position of relativity of truth, and the consequent evaporation of knowledge, leaving only knowers in its place. A result of this stance is the realization that knowledge exists, and there are ways of distinguishing between knowledges of greater or lesser truth value.

Acknowledging the sociality of knowledge, we therefore need a theory to understand the role of society and power in knowledge and schools as pedagogic institutions. Here, I will review the theories of Basil Bernstein, introducing his conceptual vocabulary which has proven highly valuable to think through and describe these issues being raised. His ideas are used here to distinguish between knowledge types; to elaborate the process of pedagogizing knowledge; and to give greater specificity to curricula and pedagogic action. Perhaps a suitable question to serve as a guide to the initial inquiry to follow would be: what does it mean when we say that knowledge is socially constructed?

## 1.    Between two poles

Recall that in the first chapter that one of the warrants for change in the curriculum and pedagogy of science education appeared to be derived from the sociality of knowledge. That is to say, because scientific knowledge has been shown to be a product of human activity, and because humans are fallible, therefore scientific knowledge (and generally, all other forms) is fallible. In an interesting coincidence, two researchers managed to publish papers in the same year, both discussing the similar issue of the implications of sociality of knowledge to the science curriculum. The terms of the debate, for Douglas Allchin (2004), in his somewhat provocatively titled Should the sociology of science be rated X, was between the normative and the descriptive nature of science. For Roy Nash (2004), it was between the necessary and the arbitrary. Both, however, hold similar arguments about seeking balance between both poles. I will rehearse their arguments below, as a means to introduce some of the more sophisticated concepts to follow in this chapter.

### 3.1.1 Normative–descriptive

Allchin begins by noting that there have been historical precedents for pointing out the socio-cultural investedness of the scientific venture, from the economic class divisions used in the debates on phrenology, to the mirroring of political views in the arguments concerning the nature of vacuums between Robert Boyle and Thomas Hobbes. More recently, the system of mass IQ testing (Gould, 1981) and its use, supported by science, may have contributed ultimately to denying the immigration of Eastern Europeans into the United States, and their consequent high death toll in the mechanisms of Hitler's Final Solution. In other words, there has been evidence of abuse of scientific authority, and for some, this becomes a source of concern as the sociology of science appears to threaten its legitimacy and reduce it to mere politics. Allchin dismisses the extreme boundaries:

> It would be foolish to suggest that the whole of science is a lie because it is nothing but fraud. Yet it would be equally blind to contend that cases of fraud are so rare as to be hard to find [ …] It would be dishonest to deny or discount fraud. It would be equally inappropriate to condone it or legitimize it. Here, one can perhaps detect a fundamental tension in how one construes "nature of science". Is it the real or the ideal? Is it the "is" or the "ought"? The ambivalence between the normative and descriptive is critical. (p. 936)

Distinguishing between macro-sociologists who study science from the level of the organization and micro-sociologists who study the individual practices of scientists, Allchin notes that the latter has produced particularly "inflammatory" conclusions "because they claim to explain scientific knowledge causally" (p. 937). Specifically, sociologists of science like to point out that scientific knowledge is 'constructed', or 'socially constructed'. A common response to such allegations of the impropriety of scientists (and by implication, science itself), is that these acts do not belong to the mainstream of science, but rather, are indicative of pathological science. However, this move re-

veals an important underlying tendency to cast scientific knowledge as perfect, error free, and "able to guarantee its claims in every instance" (p. 939). Thus, for Allchin, the lines of the debate between philosophy and sociology are drawn.

Reviewing some prominent scholars for their views on this issue, he notes that taking into account contemporary sociological knowledge, a conciliatory position may arise: (i) a diversity of perspectives is essential to achieve the 'strong objectivity' criteria proposed by Sandra Harding (1991); (ii) Helen Longino (1990 in Allchin, 2004) claims that productive discourses that mark the production of objective knowledge occurs in critical communities; it is the sociality of practice that guarantees true knowledge; and (iii) Miriam Solomon (Solomon, 2001 in Allchin, 2004) insists that objectivity can only emerge at the level of the social. In sum, the position Allchin takes is one of compromise: while he does not take a stand with regard to the fallibility of scientific knowledge, he proposes that the sociology of (scientific) knowledge offers us means to achieve objectivity through the social.

### 3.1.2    *Necessary–arbitrary*

Writing from a more general standpoint of curriculum theory, Nash takes as his starting point the task of undoing what may be some of the excesses of the once 'new' sociology of education, the project most closely associated with the work of Michael Young (1971) as introduced in the last chapter. Nash (2004) notes that:

> When Bourdieu and Passeron (Bourdieu & Passeron, 1977) declared that, '[a]ll pedagogic action (PA) is, objectively, symbolic violence insofar as it is the imposition of a cultural arbitrary by an arbitrary power', they issued what quickly became the manifesto of a generation. (p. 606, emphasis in original)

Nash rehearses some of the major arguments of the sociology of knowledge, especially those of Bourdieu and Bernstein, which essentially make the case, as the above quotation points toward,

that school knowledge is arbitrary. That is to say, "middle-class and working-class concepts of knowledge are different, basically as a consequence of their antagonistic positions in the division of labour, and that the school has an arbitrary preference for the former at the expense of the latter" (p. 608).

Seeking a deeper analysis of this issue, Nash reframes the argument to two related problems: "First, what principles and practices confer and sustain knowledge hierarchies? And, secondly, what principles and practices control social access to knowledge? Nash argues that a competing philosophy, critical (scientific) realism, has shown promise in recent years in providing a different perspective to these and related nexus of issues surrounding power, knowledge and truth. If scientific realism is right, proposes Nash, the implication for the curriculum would be that its fundamental character is less arbitrary, and more universal than assumed under a sociological framework like Bourdieu's. Critical realism, much like the conciliatory position advocated by Allchin above, holds the following premises (p613-615):

• physical and social entities of the world exist: there is a material world, and human beings are capable of gaining an accurate knowledge of its nature, and have succeeded in doing so across a broadening range of natural phenomena.

• the test of reality is demonstration: we are able to check at least some of these theories against what the world is actually like and so gain accurate knowledge of it.

• knowledge is what is known by particular people, and what people know may be compared, to a greater or lesser degree, with the way things are.

• as a corollary: the demonstrated knowledge of the science and the social tools of its production must be given a central place in the school curriculum.

• the role of science is to investigate the structures of the world and, thus, establish factual truth, not to 'search for the truth', which is a question for semantic enquiry.

For Nash, the implications for the science curriculum are immense. From a realist position, Nash believes that to be educated denotes the possession of "concepts and methods competent to reveal the structures of the physical and social world" (p. 618), not necessarily the possession of knowledge with high exchange value. Acquisition of these scientific and other forms of knowledges that allow individuals to know the world as it is confers power, "not power over nature but over oneself in relation to nature" (p. 619). In addition, knowledge allows us fuller participation in the decision making politics of communities:

> An informed participation in many areas of organized life, as a citizen and as a member of different communities, can only be enhanced by a scientific education. Debates about environmental and planning issues, often hotly contested, are effectively closed at the highest level to those with an uncertain grasp of the concepts and methods of modern science. (p. 619)

As for pedagogical strategies, Nash rejects the conventional constructivist approach of getting students to 'think/act like scientists'. If students were to behave like scientists, then we should rightly respect the theories they generate at equal level to that of scientists. However, Nash is clear that:

> This discourse is grievously in error. It is wrong in suggesting, if not actually stating, that one theory is as good as another; wrong in thinking that school children can, in fact, re-discover Galilean science (which is highly sophisticated and actually contrary to common sense); and wrong about the appropriate role of the science teacher. Anti-realist conceptions of science, moreover, undermine the scientific project itself by downgrading the significance of demonstration and the possibility of more or less accurate knowledge. (p. 620)

In sum, Nash turns out as strong advocate for the inclusion of a critical scientific realist position in science education specifically, but curriculum studies generally, counter to what may be the more fashionable intellectual fashion of social constructivism in education.

These two researchers have pointed out the boundaries and participants of the argument that I wish to pursue. Fundamentally, I am pursuing a curriculum inquiry in the philosophical sense by examining questions of the nature of knowledge, truth, and the role of power. Because uneven distribution of knowledge has social outcomes, a thoroughgoing social theory has to also play a significant role in this study. If the researchers in the earlier chapter may be interpreted as in some way supportive of the arbitrary nature of the school curriculum, it is in this chapter that I wish to develop the case for the necessary. A key concept for this approach has been the social realist perspective to knowledge. While Nash has used realism to derive some educational implications, the reasons for supporting realism over constructivist or other perpectives have not well defended in his paper. For this, I will turn to the work of Rob Moore, which I review below.

## 2.      On the sociality of knowledge

Moore (2007) writes that a prevailing concern in the sociology of education, and educational studies more generally, has been the apparent conflict between the sociology of knowledge and epistemology. Describing the latter as a concern with establishing the a priori conditions for justified true beliefs, Moore notes that in contrast, the sociology of knowledge has "attempted to recover the relationship between knowledge and the social and historical conditions under which it is produced and accepted as such" (p. 27)[3]. A dominant paradigm for these sociological studies has been

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3.    Hence, for example, in the sociology of science education, we have studies like those of Latour (1993), declaiming any possibility of specialness in the production of scientific knowledge.

the revelation of the social character of knowledge, especially in unmasking the standpoint and so-cial interests of parties privileged by the espousal of such knowledges. Once the sociality of these knowledges has been established, these knowledges stop being "candidates for knowledge in the strong epistemological sense" (p. 27). In other words, knowledge (and, consequently, objective truth) has evaporated, and replaced by knowers and their biases. This ultimately opened up the path for standpoint theorists and other users of the 'discourse of voice' to claim epistemic privilege due to their exclusive positioning and experiences, typically of oppression (see, e.g., Harding, 1991). Alternately, speakers will take up the mantle and speak on behalf of the marginalized, but as we have seen above, these arguments ultimately falter in trying to make non-relativistic claims while being firmly rooted in relativism:

> To do its job, sociology of knowledge must demonstrate the sociality of knowledge, but in doing so it demonstrates that there is no knowledge because truth claims are demonstrated to be always relative to a context of some kind and partial rather than disinterested. By doing its job, the sociology of knowledge erases its own object, and because it is itself a form of knowledge, its own rationale for existence (it can have no knowledge of its own object because the only knowledge it can produce of it is that that object does not exist, in which case, neither does the sociology of knowledge as a form of knowledge—a classic instance of the basic conundrum of relativism). By doing its job, the sociology of knowledge does itself out of a job! (Moore, 2007, p. 28)

Moore surveys the the range of positions taken by theorists, from the postmodernists, positiv-ists and the constructionists, who all hold on to the principle of foundationalism, that is, truth must be non-social in character. For the postmodernists, foundationalism is held while they argue that asociality is unobtainable, and hence, there is no truth. Ironically, postmodernist relativism "implicitly assumes the very foundationalist principle that underpins the positivism that they see themselves as radically subverting" (p. 29). Constructionists argue that knowledge is a social con-struction and deny the existence of objective reality. Comparing positivists and constructionists,

both hold on to foundationalism, but while positivists claim that knowledge can be both asocial and infallible, constructionists deny that possibility. However, both parties:

> give priority to the form of language in the determination of truth claims. For positivists this would be a single language of unmediated experience grounded in sense-data and organized as propositional logic. Constructionists agree that truth is discourse relative, but deny that the particular language prescribed by positivism is possible. Hence, there are as many truths as there are languages. (p. 34)

Additionally, both positivists and constructionists conflate knowledge with knowing, located within the consciousness of the subject; and ground knowledge in experience, although there are minor differences. Ultimately, however, Moore takes the position that these two positions constitute the epistemological positions of absolutism and relativism, both of which he finds untenable.

In contrast, Moore proposes social realism, which takes the middle way between these epistemological extremes. In his description, social realism disavows foundationalism, and is committed to a fallibilist model of truth, that is to say, that all truth claims are provisional and open to revision. In addition and importantly, realism holds that some ways of knowledge production are demonstrably superior to others. Realism:

> sits between absolutism and relativism. It agrees with positivism that we do indeed have knowledge, but denies that that knowledge is infallible. It agrees with constructionism that knowledge is social but does not see this as implying that truth is relative. (p. 35)

The sociality of knowledge for realism lies not in the sense that knowledge is dependent on discourse, but in the sense that knowledge production is socially organized. Instead of locating knowledge in the experiences of knowers (as the positivists and constructionists do), realism locates knowledge in intellectual fields: "Such fields have structures, principles and logics of their own that are only ever partially given to their agents, but which can constitute objects of knowledge in

their own right (the objects of a realist sociology of knowledge)" (p. 36). Instead of the reduction-ism found in positivism and constructionism, Moore suggests that the concern for realism is with the emergent properties of knowledge producing fields. He describes this as a concern with the ability of fields to produce knowledge that transcends limited contexts of space and time:

> It is partly in terms of this capacity that some ways of producing knowledge are more reliable (cognitively more powerful) than others. Their knowledge applies transcultur-ally in a non-discriminatory manner. Crucially, it is the emergent properties of know-ledge that provide for it an irreducible dimension that cannot be accounted for by ref-erence back to some external social interest. (p. 36)

In this derivation of the significance of social realism as a principle for guiding curriculum theory, one begins to appreciate the primacy of privileging knowledges that possess a better correspond-ence with reality, or in other words, possess a higher degree of truth value. Here, it is important to pause and take stock of the 'epistemological landscape' so to speak, and to acknowledge that numerous other respectable edifices exist as coherent and internally self-consistent descriptions of the nature of truth and reality, and that the interpretation presented here is certainly not definit-ive. For example, poststructuralist scholars have studied the use of signs and symbols as the inter-mediaries between truth and reality, leading to, at one extreme, thoroughly skeptical positions like "The Gulf War did not take place" (Baudrillard, 1995), a logical outgrowth of a position which re-jects the existence of objective reality[4]. The aim of this project is not at all to compare epistemolo-gies, repudiate these alternatives and assert the primacy and dominance of social realism over all else, but to deliberately select a particular ontological and epistemological framework and work through its strengths and weaknesses, in a philosophically consistent manner, through to its logical conclusion in some empirical context that may be familiar to readers. At the same time, this is not

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4.   and to which, an equally strong rejection may be found in, for example, the work of Christopher Norris (1992)

to say, however, that the choice of social realism is necessarily an arbitrary one; for the purposes of this research and considering the influence of personal motivations and research upbringing, the choice of framework recommends itself. For example, given the sociological interest in the effects of curriculum on society and vice-versa, current thought within the academy[5] appears to favour a form of social realism and simultaneously express a certain ennui toward the inescapable relativism implied or expressed in some other approaches. Understandably, in the North American context, the approach favoured in this project finds itself occupying a minority position; this challenge is acknowledged with the understanding that adopting such a position is not likely to automatically win this project a great deal of converts and adherents given the general unfamiliarity of social realism within the North American research community. The reader is hence requested to temporarily 'check in' any philosophical 'luggage' at the door and take a brief detour into possibly unchartered territory, safe in the knowledge that no conversion is being attempted, nor insults, real or perceived, are ever intended.

In this section, we begin to see now that knowledge, and hence, the curriculum is not arbitrary, not infinitely pliable, and that there exist ideas which possess obligatory qualities due to its greater correspondence to reality. Our next task is to develop curriculum principles grounded in these philosophical perspectives. For this, it would be insightful to consider the work of Michael Young.

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5.   at least in the academic communities of the United Kingdom, Australia, and South Africa, but not so much in North America.

## 3. Curriculum theory comes full circle: Michael Young and knowledge

As noted in the previous chapter, Michael F. D. Young has been one of the major figures responsible for launching the movement of the sociology of curriculum which he and others dubbed the 'New sociology of education' in the 1970s. Based on problematizing the epistemological grounds of school knowledge, and developing more fully a sociological understanding of the school curriculum, the project has enjoyed a fair of success, until the 1990s and the turn of the century, again, also as outlined in the previous chapter. Upon challenges mounted by Ladwig (1996), Moore and Muller (1999), and others, Young has publicly acknowledged some errors in his earlier work, and has since set forth significant revisions of his work. To recapitulate, recall Young (1971) was initially concerned with the apparent non-neutrality of the school curriculum, especially given the social constructivist/constructionist perspective which essentially contends that knowledge is a social arbitrary. From this perspective, knowledge forms in school were thought to reflect the interests of the dominant classes, often at the expense of the marginalized classes, for whom alienation from these dominant cultural practices meant that acquisition of these privileged knowledges was often difficult. This was also in addition to the fact that by the interests of the marginalized classes were often not reflected in the school curriculum.

Moving forward to the early part of this century, Michael Young's has since taken a more moderate, if not dramatic, stance. In a paper from 2008, Young states his revised position:

> Our concepts and theories have a history and a structure that we have to take account of; they vary over time and across cultures, but they are not infinitely variable. Second, the world (both natural and social) of which we have knowledge is itself structured and not arbitrary, even if we can never be absolutely certain what those structures are [...] Although social and therefore not beyond history, knowledge structures (and therefore curricula) face both learners and teachers as real constraints and cannot, as some of us once thought, be "constructed away" by political or pedagogic action (Young &

> Muller, 2007). In this sense, philosophers such as Pring (1972) and science educators such as Jevons (1972) were right, and I (Young, 1974) and other "new sociologists" were wrong when at the time we set no limits, at least explicitly, on the possibilities of constructing the world differently. These limits, too, are themselves social in origin, albeit in very specific ways. (Collins, 1998)

At points throughout this paper (Young, 2008b), Young makes repeated appeals for the return of an epistemological basis to the sociology of curriculum, in line with much of the critique around the turn of the century:

> Critical curriculum studies displays how subordinate groups are discriminated against. However, without a theory of knowledge, it has no basis for suggesting what a system that discriminated less against subordinate groups might look like. Nor can it argue convincingly that doing away with or even modifying the characteristic features of the current system—its subjects, its pedagogic hierarchies, its external examinations, and its textbooks—would make discrimination and inequality less rather than more likely. (p. 9)

Young acknowledges that the conflict experienced by students over the culture of the curriculum and their own represents a "fundamental pedagogic problem that teachers always face" (p. 10), and that this conflict is often greatest for the marginalized students for whom their social circumstances often represent particular barriers to effective acquisition. However, this does not absolve sociologists of education from tackling the hard questions of the nature of knowledge that should form the basis of a curriculum that is maximally accessible to the largest majority of students.

A further concern has been with the recent changes that have been occurring throughout school systems on a global basis—that of an increasing tendency to reduce curriculum content, primarily of the 'technical' and subject-specific content areas. This movement has arisen largely in part due to state pressures to involve an ever-widening proportion of each school-going cohort.

However, Young contends that if we can agree that one of the key roles of school is the transmission of knowledge:

> [...] then the curriculum must assume that some types of knowledge are more worthwhile than others, and their differences must form the basis for the differences between school or curriculum knowledge and nonschool knowledge. (p. 13)

It is here that Young introduces his distinction between knowledges of the powerful and powerful knowledges. Specifically, while the idea of the knowledges of the powerful is associated with Marx's "well-known dictum that the ruling ideas at any time are the ideas of the ruling class", powerful knowledges instead represent, in one sense, a better correspondence between the idea and the underlying material reality:

> This [powerful knowledge] refers not to the backgrounds of those who have most access to knowledge or who give it legitimacy, although both are important issues. Powerful knowledge refers to what the knowledge can do or what intellectual power it gives to those who have access to it. Powerful knowledge provides more reliable explanations and new ways of thinking about the world and acquiring it and can provide learners with a language for engaging in political, moral, and other kinds of debates. Accessing powerful knowledge is, if not always consciously, what parents hope their children will achieve in making sacrifices to keep them at school; they hope that their children will acquire knowledge that is not available to them at home. In modern societies, powerful knowledge is, increasingly, specialized knowledge; and schooling, from this perspective, is about providing access to the specialized knowledge that is embodied in different knowledge domains. (p. 14)

Young charges that curriculum researchers have neglected the epistemological grounds for the selection of school knowledge, and the conditions for the successful acquisition of powerful knowledges. Without a significant theory for the structuring and distinction between knowledge forms, Young argues that we are left unable to distinguish between school and non-school knowledges and its conditions for acquisition. In this place, he offers Bernstein's theories of horizontal and hierarchical knowledge forms, and for the analysis of pedagogy, classification and framing, which I

will review later in this chapter. Young warns against curricula that, in the interests of connecting knowledge to the immediate experiences of learners, neglects to develop powerful knowledges: "It does them no service to construct a curriculum around their experience (context-dependent knowledge) on the grounds that everyone's experience is equally valid, at least for them; if schools do no more than validate the experience of pupils, they can only leave them there" (p. 15)

Significantly, Young also argues against the dominant rhetoric for schools to change and adapt to social pressures; Young argues for the need to distinguish between resistance to change that "preserve the conditions for acquiring powerful knowledge and those forms primarily concerned with the preservation of particular professional interests and privileges" (p. 17). In particular, care must be taken to ensure that changes made to school systems are not at the expense of specialist knowledges of teachers.

Returning to this study, we see much that we can use from this later revision in Young's thought. To begin, while acknowledging the concerns of the environmental and social justice movement, there arises from Young the concomitant issue that these essentially politically motivated[6] curriculum proposals to the science curriculum constitute meaningful changes that do not diminish the power of school knowledges in any way. This is certainly not necessarily a call for curricular conservatism, as it is quite clear that we have a duty to ensure that learners acquire a more accurate knowledge of the state of the natural and social environment. However, if Young is correct, there remains much work to be done in determining the conditions for the effective acquisition of these knowledges, especially taking into account that we do not sacrifice teachers' pro-

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6.  regardless of the liberatory nature of the political intention.

fessional knowledge in pedagogizing scientific content in the process. For now, I will review some of Young's ideas surrounding the distinction between school and non-school knowledges.

### 3.3.1 On truth and knowledge

Michael Young was clear that without a theory of knowledge, the sociology of school knowledge did not possess a means to propose alternatives to the current curricula, biased as it may be shown to be. The fundamental question underpinning this strand of Young's research has been the quest to discriminate between school and non-school knowledges, based on the underlying assumption that schools should transmit, or facilitate the acquisition of, powerful knowledges. While this may sound eminently straightforward at the outset, the façade starts to break down when hard questions begin to be asked. Considering the project of the researchers reviewed earlier, we could ask: how do we know that knowledges of environmental and social issues belong in the school classroom? If we could answer that these knowledges belong, as they are, in some sense, 'true'; or provide greater correspondence to reality; the question quickly reduces to the age old problematic of truth and its criteria, and the possibility for objective knowledge.

Young and Muller (2007) began their paper (and chapter, see, Young, 2008a) with the cogent observation from Bernard Williams that the commitment to truthfulness has recently been set against a skepticism about truth itself—"whether such a thing as truth [...] can be more than relative or subjective or something of that kind" (Williams, 2002, in Young & Muller 2007). The latter is said to corrode the former; that is to say, the recent arguments of social constructivists and post-modernists who claim to have dismantled any remaining foundations for objective knowledge "serve only to deflect us from facing the really difficult questions about knowledge and truth that we cannot avoid if sociology is to offer more than – as some postmodernists claim—a series of stor-

ies" (Young & Muller, 2007, p. 174). Comparing some social constructivist approaches to the sociology of curriculum with muck-raking journalism, Young & Muller claim that both shared a common strategy of debunking even though both could be said to seek truthfulness. For the movement in the sociology of curriculum, "[i]t knew the truth—the link between power and knowledge—and set out to show how this truth manifested itself in the school curriculum" (p. 176).

The primary concern with Young and Muller has been with the critique of social constructivism as a major movement in education. They begin by noting how social constructivism has apparently provided:

> teachers and students of education with a superficially attractive but ultimately contradictory set of intellectual tools. On the one hand it offered the possibility of intellectual emancipation and freedom through education – we, as teachers, students or workers have the epistemological right to develop theories and to criticize and challenge scientists, philosophers and other so-called experts and specialists. Furthermore, in some unspecified way, this so-called freedom was seen as contributing to changing the world. This emancipation from all authoritative forms of knowledge was linked by many to the possibility of achieving a more equal or just world, which for some (but not all) meant socialism. On the other hand by undermining any claims to objective knowledge or truth about anything, social constructivism, at least in some of the ways it was (and could legitimately) be interpreted, denies the possibility of any better understanding, let alone of any better world. For obvious reasons, however, this denial tended to be ignored by educational researchers, at least most of the time. (p. 181)

Social constructivism has also seen the rise of the 'activity/practice turn' in educational studies, often associated with the liberatory promise and apparently democratic access rendered by the various technological and information-communication tools. These movements are supported ultimately by social constructivist ideas that "suppress hierarchy, or at least render it invisible" (Muller, 2006, in Young & Muller, 2007). Social constructivism has also been associated with calls for

knowledge to be 'socially relevant'—which Young and Muller point out to be "utilitarianism thinly veiled beneath a moral correctness" (p. 185).

Young and Muller do not claim an absence of sociality in knowledge; in fact, it is the social character that remains "the only reason knowledge can claim to truth (and objectivity)" (Collins, 1998, in Young & Muller,2007). Further, they claim that this understanding of the sociality of knowledge is the only reason for preferring some curriculum principles to others. Seeking a more positive conception of truth and knowledge, Young and Muller draw from the theories of Emile Durkheim. For Durkheim, an issue he had was with the a posteriori condition for truth that was held by pragmatists and utilitarians, that is, that knowledge is true depending on the consequences. Knowledge had to be a priori in the social sense, in that "it is prior and relies on what society has demonstrated to be true" (p. 185). By extension, Young and Muller find issue with social constructivists for whom knowledge is based upon the interests of individuals or societies:

> Just as with pragmatism we are left with consequences, so with social constructivism we are left only with interests. In each case, both truth and knowledge disappear [...] As Durkheim pointed out, satisfying a need could never account for the essential impersonality of truth that is not related to any specific individual, standpoint, interest or need [...] Sometimes the truth does exactly the opposite to satisfying a need and does not seem to be in one's interest; however, that does not stop it from being true. (p. 185)

To summarize then, Young and Muller take that knowledge has a social basis, but deny the social constructivists' reductionism of this social nature to privilege the interests of knowers. In other words, curriculum proposals that take as their foundational philosophy the notion that knowledge is arbitrary and ultimately the residues of struggles over power and positionality are mistaken. But this does not resolve how knowledge came to be, and the conditions for truth. For this, we need to

take a deeper look at Young's interpretation of Durkheim, especially in his distinction between sacred and profane knowledge forms. I will turn to this in the next subsection.

### 3.3.2 *The sacred and the profane: On orders of knowledge*

Michael Young drew heavily on Durkheim's study of knowledge in the former's book Bringing Knowledge Back In: From Social Constructivism to Social Realism in the Sociology of Education (Young, 2008a). As the title of the book suggests, and as I review above, a major project for Michael Young has been the repudiation of social constructivist notions, especially of the form that leaves out the possibility for knowledge and truth. If social constructivist perspectives are mistaken, there still remains however the task of explaining the existence of knowledge—where was it 'located', and how did it come to be?

A starting point for Durkheim was his initial observation of the the social reality of religion in primitive societies, a form of 'collective representation' which did not originate in individual minds, but instead grow out of the 'collective effervescence' of communities. Durkheim also argued that although the initial form of knowledge was religious, this model of the growth of religious knowledge represented the prototype for the development of all forms of abstract, theoretical thought. A key distinction that Durkheim made was between the orders of knowledge he termed as the sacred and the profane, which he argued was a feature of all the primitive societies he studied. This distinction was fundamental, and provided a means to discriminate between the everyday, profane knowledges of the practical, immediate, and concrete; and the sacred—invented, arbitrary, and collective:

> [T]hese systems of concepts had, for Durkheim, am objectivity arising from their shared, social character, and from the fact that they were external to the perceptions of individuals, sacred concepts are relatively fixed and unchanging as well as exhibiting a distinctive feature of knowledge and truth—individuals feel under external pressure to

accept them. For Durkheim, when truth and knowledge are at stake, the issue of choice does not arise. (Young, 2008a, p. 41, emphasis in original)

Young surmised that the study of knowledge in religions was important for Durkheim not as evidence of God, but due to its role in maintaining social solidarity, and also because the orders of knowledge in religion formed the prototype "for all other types of abstract thought, such as modern science, that consist of unobservable concepts. In other words, the totems of the aborigines and he gas laws of the physicist were, in form at least, identical for Durkheim" (p. 41).

Durkheim highlighted two important features of sacred knowledges: (i) because sacred knowledges are formed out of a collection of shared concepts not tied to any particular object or events, sacred knowledges allowed individuals to make connections between objects and events that would not have otherwise been, based on everyday experiences; (ii) since sacred knowledges were not anchored in pedestrian experiences, it allowed individuals to project beyond the present to possible futures. However, this was not an effort to develop a hierarchical relationship between knowledge forms. If our knowledge were to be limited to the profane, there would be limited means for making sense of the world; in addition to the issue that context specific, profane orders of knowledge were not well suited as a basis for context-transcending objective knowledge. On the other hand, everyday life would be impossible if we could only rely on theoretical knowledge.

The implications for education of Durkheim's ideas follow from an understanding that there exists objective knowledge, independent of knowers, situated in society, and was powerful not because it provided solutions to practical problems, but because it gave individuals a "sense that they could not generate from experience of who they were and where they were going" (p. 61). Along with these knowledge structures are "rules, codes and values associated with different specialist tra-

ditions which make well grounded claims about knowledge and how it is generated and acquired" (p. 63). For Young, there is a sense that a strict insularity between the context bound everyday practical knowledges and the abstract theoretical knowledges is a condition for the effective acquisition of expert knowledges: "New knowledge and new curricula are generated when researchers or learners acquire and build on existing knowledge and concepts from specific fields and disciplines to make sense of or transform the world" (p. 64).

### 3.3.3 *Summary and implications–Michael Young and the curriculum*

To recount, it is clear that Michael Young has decidedly moved on from his earlier attachment to social constructivist philosophies of knowledge. From his perspective, social constructivism has given license to curriculum researchers to dismantle the traditional subject boundaries that were ostensibly reflective of unjust power relations. This position is mistaken, and Young has spent a considerable amount of careful effort to show how this is so, and to provide an alternative framework for distinguishing between school and non-school knowledges. Young acknowledges that the principle of insularity of the subject boundaries have been used to support "profoundly conservative doctrines in defence both of the curriculum status quo and of claims that, despite the steady increase in numbers gaining higher level qualifications, both school and university standards are falling" (p. 36). While it is not necessarily Young's intention to provide support for such conservative agenda, he remains in support of the principle of insularity, on the grounds that these classifications have "epistemological and pedagogic significance; in other words, they relate in fundamental ways to how people learn and how they produce new knowledge" (p. 36). To emphasize: knowledge places limitations on the subject boundaries and conditions for the effective acquisition of powerful knowledge; knowledge forms are not infinitely miscible.

What may be some implications for this project? If Young is correct, and that there exist epistemological and pedagogic prices to pay for hybridization and weakening subject boundaries, one major outcome could be that the difficulties teachers inevitably report when introducing new curricula may not simply be due to a lack of preparation or expertise with the revised/merged content. Instead, these difficulties may be signs of inherent conflict that arise due to the subject matter in itself. In considering the question that Roth and Barton (Roth & Barton, 2004) pose at the beginning of their book regarding the utility of learning apparently esoteric concepts, we now have the beginnings of a reasoned response. We want students to learn these sophisticated and 'irrelevant' concepts not only in the supposedly vain hope that some day they will need to use it, but also because of the acquisition of the "rules, codes, and values associated with the different specialist traditions" requires content for its contextualization. More significantly, it is the ability of abstract, theoretical concepts to enable us to conceptualize objects and events beyond our limited daily experiences, that illustrate the power of knowledges. Young and Muller write:

> As Penrose argues in his remarkable book The Road to Reality (Penrose, 2006), time and time again, mathematical concepts at extraordinary levels of abstraction (one of his examples is the patterning of prime numbers) and with no apparent relationship to the material world turn out to be integral to our understanding of both the structure of the universe and the structure of matter. (Young & Muller, 2007, p. 189)

It is surely this sense of power that we should aspire for learners to acquire, the same sense advocated by the 'wise old men' in the story of the saber tooth curriculum (Peddiwell, 1939) who continue to support the teaching of a timeless, apparently 'outdated' curriculum.

In the next section, I will continue to review some of the concepts derived from Bernstein with regard to the classification of school and non-school knowledges. In some way, Bernstein's theories extend the sacred/profane distinction to explain the internal features of their construc-

tion and offer a more nuanced appreciation of the sociality of knowledge and the processes of pedagogizing.

## 4. Power, knowledge, and schools: Working with the ideas of Basil Bernstein

Basil Bernstein was originally famous for his work on the classification of linguistic forms in use in pedagogical settings. With a career that spanned from the 1960s till the late 1990s, Bernstein's scope of ideas is expansive, and like any well developed theoretical edifice, contains numerous entry points and subtle distinctions that extend his projects' usefulness in many different directions. It is quite obvious at this outset that I can only use a selected subset of his work; specifically, I wish to introduce and work with his theories on: (i) the process of recontextualizing knowledge; (ii) discourse and structuring of knowledge; and (iii) related to the prior, his theory of classification and framing. The questions that these theories provide better understanding of may be thought of quite simply as: (i) Are there any differences between practitioners' knowledge forms and school knowledge, and what is the process whereby knowledge becomes 'pedagogized'? (ii) Are there any differences in the types of knowledges? and (iii) What role does power play in the maintenance of knowledge boundaries, and how is this boundary maintenance carried out? I introduce these concepts now as they will become useful in the analysis of my empirical data. These ideas will become the elements of a conceptual vocabulary that allows for a more refined description of the curriculum and pedagogical contexts that form my study.

### 3.4.1    Knowledge recontextualization

As mentioned in the previous section, one of the central problematics of Bernstein's work was a desire to understand the role of power in the production, use, and dissemination of knowledge. Noting that language devices employ rules governing the translation of meaning potential into ac-

tualized communication, and that these rules are not necessarily neutral, but instead regulate what may be said, Bernstein (2000) constructed a similar model for pedagogizing knowledge. In the same way as the language device where, for example, certain meaning potentials are excluded from realization[7], the pedagogic device contains rules that "continuously regulates the ideal universe of potential pedagogic meanings in such a way as to restrict or enhance their realizations" (p. 27). For the pedagogic device, Bernstein lists three hierarchically related rules which he terms the distributive, recontextualizing, and evaluative rules. The evaluative rules are derived from the recontextualizing rules, which are ultimately derived by the distributive rules. To explain the nature and role of the distributive rule, Bernstein first points out that in both small-scale non-literate societies and contemporary modern societies, there exists a profound similarity in the way these societies structure meanings. Meanings always exist in an indirect relation to a specific material base, forming what Bernstein called a 'potential discursive gap':

> a site for alternative possibilities, for alternative realizations of the relation between the material and the immaterial. The gap itself can change the relation between the material and the immaterial. This potential gap or space I will suggest is the site for the unthinkable, the site of the impossible, and this site can clearly be both beneficial and dangerous at the same time. This gap is the meeting point of order and disorder, of coherence and incoherence. It is the crucial site of the yet to be thought. (p. 30, emphases in original)

Importantly, Bernstein points out that power "will regulate the [realization] potential of this gap in its own interest, because the gap itself has the possibility of an alternative order, an alternative society, and an alternative power relation" (p. 30). Ultimately, the distributive rules can be said to

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7.    Bernstein used, as an example, the difficulty in finding a gender-neutral replacement for the term *mastery*.

"mark and distribute who may transmit what to whom and under what conditions, and they attempt to set the outer limits of legitimate discourse" (p. 31).

The recontextualization rules are a set of principles which govern how particular knowledge forms may be pedagogized, by governing the processes of selective appropriation, refocussing, and the relation of other discourses to its own order. When the process is complete, the pedagogized discourse becomes essentially distinct from the discourse in the field of production of the knowledge. For example, the physics of practitioners bears little resemblance to the physics of schooling; in the former, there are no explicit rules that determine if one is actually 'doing' physics, whereas in school physics, textbooks with authors say what physics is, authors who are rarely physicists working in the field of knowledge production. Such authors belong to what Bernstein terms as the recontextualization field, of which he distinguishes between the official and the pedagogic. The official recontextualizing field (ORF) is dominated by the state and state agencies, while the pedagogic recontextualizing field (PRF) "consists of pedagogues in schools and colleges, and departments of education, specialized journals, private research foundations" (p. 33). If actors in the PRF are able to exert influence on pedagogic discourse independent of the ORF, Bernstein argues, this would be evidence of "autonomy and struggle over pedagogic discourse and its practices" (p. 33). Ultimately, the evaluative rules are that which "condenses the meaning of the whole device" (p. 36); constant evaluation becomes the key to the maintenance of the order of the pedagogic practice.

Clearly, these ideas are highly productive and offer us ways of thinking about the curriculum. For one, the potential discursive gap can now be seen as an entry point toward changing the world; if we could change the word and alter the meaning potential, we may be see things differently and,

therefore act differently. However, written right into this formulation of the discursive gap is the idea of the distributive rule, and its accompanying limitations—one needs to understand these rules and their functioning in society. These rules include possibly the principles which support the power structures which hold the distributive rules in place, giving credence to the discussion reviewed earlier about the mechanism of the discourse of voice. Specifically, there exist ideas whose hold on the social imagination are wholly due to their being (arbitrary) ideas of the powerful. Conversely speaking however, there also exist ideas which are powerful in itself. Considering a historical view, it is easy to identify ideas like slavery, racial superiority, or eugenics (see, e.g., Gould, 1981) as examples of the former, supported ultimately by the 'word of god'; while the progressive supplantation of scientific ideas by newer revisions as an example of the power of ideas in themselves.

The issue then becomes the process by which we come to judge ideas as powerful knowledges or knowledges of the powerful. At least one means of assessment should be the degree to which these ideas allow us, for want of a better word, mastery over our material world, or a better correspondence to reality. Taking the example of science, it should be clear that scientific knowledge is not powerful because powerful scientists, in some grand conspiracy, choose certain ideas over others, but rather, it is that scientists are powerful because they subscribe to a certain set of ideas, which confer on them more effective means of understanding and operating with the world. These ideas have material consequences over the world, and offer to those who espouse them, power over the material world, regardless of the context of the creation of the idea. Certainly, as others have noticed, this power may be put toward great evil, as the case of nuclear weapons or the eugenics movement makes clear. However, capacity does not connote inevitability; one could equally argue that there is no lockstep trajectory from mastery of the material world, to evil. The power of this

knowledge is of the form that arises from a greater correspondence to the world, that allows more elegant explanations, and predictive power over phenomena. We begin to see potential for a rational criteria for curriculum selection—that one factor should be the degree of power that the knowledge offers over the material world.

As an example of the different roles played by agents in the ORF and the PRF, Kidman, Abrams and McRae (2011) mentioned above demonstrate how science curriculum changes undertaken in the ORF which appear to empower teachers as members of the PRF ultimately short-change the teachers instead. In this case, changes were made to make the science curriculum of Maori schools, but the model that was adopted amounted to getting Maori community members come forward with suitable Maori translations for Western modern scientific concepts and objects. This move became tantamount to not recognizing the existence of a non-trivial set of indigenous Maori scientific concepts. Teachers were assigned the responsibility of changing the curriculum as they saw fit, to accommodate concepts that they believed to be absent from the official curriculum documents. However, few, if any, of them expressed confidence in their abilities to do so. In addition, there was a general lack of material resources to perform the task required. It is not just that knowledge recontextualization occurs at two different levels, and that forms of power may be exerted at different levels for different effects[8], but understanding the process of curriculum recontextualization occurring across these levels allow us a means to maximize the potential for changing the curriculum as it is ultimately delivered to students.

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8.    for instance, we should all be familiar with the (standardized) assessment tail wagging the dog of schooling.

### 3.4.2       *Discourse and knowledge forms*

Bernstein (2000) contended that discourse could be distinguished into two main categories, which he termed the horizontal and the vertical. In horizontal discourse, the knowledge types are what might be considered 'everyday' or 'common sense'. He explains:

> This form has a group of well known features: it is likely to be oral, local, context dependent and specific, tacit, multi-layered and contradictory across but not within contexts. However, from the point of view to be taken here, the crucial feature is that is it segmentally organized. By segmental I am referring to the sites of realization of this discourse [...] They are contextually specific and context dependent, embedded in on-going practices, usually with strong affective loading. and directed towards specific, immediate goals, highly relevant to the acquirer in the context of his/her life. (p. 157-159)

 In contrast, vertical discourses are specialized languages, and have the form of a:

> coherent, explicit and systematically principled structure, hierarchically organised as in the sciences, or it takes the form of a series of specialised languages with specialised modes of interrogation and specialised criteria for the production and circulation of texts as in the social sciences and humanities. (p. 157)

The first issue for Bernstein in working through this framework is the question of circulation—how do knowledge forms circulate? For horizontal, segmentally structured knowledge forms, there appear to be little relation between the knowledge acquired and mode of acquisition in one segment and the next. For example, learning to tie one's own shoelaces has no import on learning how to use a lavatory. Horizontal discourses are associated with knowledge forms that are "contextually specific, context dependent, embedded in on-going practices, usually with strong affective loading, and directed towards specific, immediate goals, highly relevant to the acquirer in the context of his/her life" (p. 159). These segmental competencies also tend to be "culturally localized, evoked by contexts whose reading is unproblematic" (p. 159, emphasis in original).

Conversely, for vertical discourses, Bernstein suggests that acquisition of this knowledge form takes place within hierarchically related structures, integrated through the level of meanings: "Vertical discourse consists not of culturally specialized segments but of specialized symbolic structures of explicit knowledge. The procedures of Vertical discourse are then linked, not by contexts, horizontally, but the procedures are linked to other procedures hierarchically" (p. 160). Vertical discourses also tended to be acquired in institutional or official contexts, through individualized graded performances.

Bernstein follows with a characterization of different knowledge forms encompassed by vertical discourses. Again, he creates a bifurcation into two terms, which he called hierarchical, and somewhat confusingly, horizontal, knowledge structures. It is probably useful to make use of archetypal knowledge forms to flesh out Bernstein's distinction; here, the contrast is between the natural sciences (hierarchical knowledge structure) versus the social sciences and the humanities (horizontal knowledge structures). Bernstein contends that: "[h]orizontal knowledge structures consist of a series of specialised languages with specialised modes of interrogation and criteria for the construction and circulation of texts" (p. 161). So, for example, in the case of the social sciences, the knowledge structures of sociology, philosophy, English literature appear to stand apart. Horizontal knowledge structures are based on collection or serial codes, as opposed to hierarchical knowledge structures based on an integrating code. Bernstein describes integrating codes as such:

> This form of knowledge attempts to create very general propositions and theories, which integrate knowledge at lower levels, and in this way shows underlying uniformities across an expanding range of apparently different phenomena. Hierarchical Knowledge Structures appear by their users to be motivated towards greater and greater integrating propositions, operating at more and more abstract levels. (p. 161)

In terms of knowledge development, hierarchical knowledge structures are said to develop when new knowledge can be shown to be more general, and more integrating that the previous theory. Conversely, horizontal knowledge structures develop knowledge by the invention of a new language, which "offers the possibility of a fresh perspective, a new set of questions, a new set of connections, and an apparently new problematic, and most importantly a new set of speakers [...] This new language can then be used to challenge the hegemony and legitimacy of more senior speakers." (p. 162).

Bernstein next contrasts the goal for acquisition for these two knowledge forms. He asserts that in hierarchical knowledge structures, "it is the theory that counts, and it counts both for its imaginative conceptual projection and the empirical power of the projection" (p. 164). While an acquisition of a perspective is unavoidable[9], this perspectival acquisition is much less tacit than the knowledge acquisition process in horizontal knowledge structures. For horizontal knowledge structures:

> [...] what counts in the end is the specialised language, its position, its perspective, the acquirer's 'gaze', rather than any one exemplary theory (although the exemplary theory may be the originator of the linguistic position). In the case of the Horizontal Knowledge Structures, especially those with weak grammars, 'truth' is a matter of acquired 'gaze'; no one can be eyeless in this Gaza. (p. 165)

Bernstein uses the example of sociology to illustrate the acquisition of 'gaze' in horizontal knowledge structures. For sociology, unlike physics (as an example of an hierarchical knowledge form), learners have some difficulty in knowing whether or not they are actually speaking, writing or using sociological knowledge in the correct sense. In addition, since horizontal knowledge structures

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9.   For example, in the natural sciences, one perspective could be that the methods of science are the only way to truth.

are composed of segmentally organized languages with distinct specialized meanings, transmission entails selection of some form, and this selection is not rational. By this, Bernstein meant that selection is not made via the assessment of the 'truth value' of each segmental knowledge, but more reflective of the power relations surrounding the act of acquisition. In contemporary times, the power nexus derive from market or state pressures on the contexts of acquisition.

The implications for education come from the popular move in education to insert segments of horizontal discourse into school subjects, either as a means to provide contextual resources for facilitating access to vertical discourses, or as resources for "pedagogic populism in the name of empowering or unsilencing voices to combat the elitism and alleged authoritarianism of vertical discourse" (p. 170). In both, the challenge remains in the inherent difficulty of the process of recontextualization: horizontal discourses are dependent on specialized contexts, which are often removed from the contexts under which acquisition is supposed to take place.

With particular relevance to proposals in science and environmental education reviewed earlier, Bernstein's perspective offers a means to reconsider some of the more exuberant proposals for curriculum change. Recall that Sauvé's (2005) scientific current in environmental education faces one possible critique that environmental education, especially of the value centred perspective is 'not' science. Bernstein's theories offers us a more concrete and descriptive means of explaining this lack of fit. Especially if we consider proposals that demand that students learn about inequities and social injustices, and we desire that schooling provide more than pedestrian knowledge of these sociological phenomena, we encounter a challenge from the process of recontextualization as "space, time, disposition, social relation and relevance have all changed" (Bernstein, 2000, p. 169). Scientific knowledge is hierarchically structured, whereas sociological knowledge, dealing with the

nature of social reality, is horizontally structured, and the pedagogical strategies suitable for the transmission of each type of knowledge may be significantly different enough that being able to deliver a comprehensive curriculum may be out of reach of most educators.

What is probably more significant here are the pedagogical implications of these theories. Specifically, if different knowledge forms require different pedagogical approaches for effective transmission[10], and different knowledge structures contain largely incommensurate partial truths, what are the implications for combining knowledge forms? Bernstein specifically points out that the insertion of horizontal discourse segments into contents of school subjects may not necessarily lead to more effective acquisition (p. 169). Here, I extend and rephrase the question to the following: Are there any limitations placed by knowledge structures on the pedagogical discourse of the classroom? In other words, could it be that by the introduction of environmentalist and social justice related concerns in science education, there may come a point where the science lesson stops being one? On the surface, this is eminently plausible—after all, if social justice related agenda are to be taken seriously, it has to ultimately draws its reserves of knowledge from the social sciences, specifically the sociological knowledges. Even without a Bernsteinian perspective, we certainly can agree that these two knowledge forms are markedly different enough that acquisition of one would potentially be at the expense of the other. To be sure, some measure of sociological content may be necessary to serve as context and motivational inducements for learners, but the 'tipping point' remains a potentially empirical issue for investigation.

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10.   or acquisition or construction, depending on one's favoured theory for learning.

*3.4.3*    *Classification and framing*

Another Bernstein concept that will be useful here is his theory of classification and framing. Deriving from his observation that researchers have focussed on the analysis of schooling as a relay for power, Bernstein argued that there needed to be greater attention into what the relay was doing, instead of only concentrating on the effects of the relay. To open up the metaphorical black box, Bernstein proposed the concepts of classification and framing to explain, respectively: (i) what power does in knowledge, and (ii) how power accomplishes it.

In classification, Bernstein (2000) explains that the term is used to describe the defining attributes between categories, instead of the typical usage of the term to describe attributes of elements within categories. This choice is made as:

> [...] the crucial space which creates the specialisation of the category—in this case the discourse—is not internal to that discourse but is the space between the discourse and another. In other words, A can only be A if it can effectively insulate itself from B. In this sense, there is no A if there is no relationship between A and something else. The meaning of A is only understandable in relation to other categories in the set; in fact, to all the categories in the set. In other words, it is the insulation between the categories of discourse which maintains the principles of their social division of labour. In other words, it is silence which carries the message of power; it is the full stop between one category of discourse and another; it is the dislocation in the potential flow of discourse which is crucial to the specialisation of any category. (p. 6)

Thus, classification may be used to describe the distinction between the discursive categories of the traditional subject boundaries, or, more generally the "division of labour in the field of production: unskilled, skilled, clerical, technological, managerial" (p. 6). Bernstein proposes that it is power that preserves the insulation between the categories. These power relations are disguised and hidden, having taken on the form of a natural order, and constructing identities that have been accepted as "real, as authentic, as integral, as the source of integrity" (p. 6). Classification can

be either stronger or weaker, as determined by the strength of insulation between the categories of discourse, gender, etc. As a consequence of stronger classification, each category "has its unique identity, its unique voice, its own specialised rules of internal relations", while weaker classification would imply "less specialised discourses, less specialised identities, less specialised voices" (p. 6). However, Bernstein is quick to add that regardless of the degree of classification, all classifications carry power relations. Classification maintains two major functions: external to the individual, classification regulates the relations between individuals, creating order, while "the contradictions, cleavages and dilemmas which necessarily inhere in the principle of classification are suppressed by the insulation". On the other hand, internal to the individuals, the insulation becomes "a system of psychic defences against the possibility of the weakening of the insulation, which would then reveal the suppressed contradictions, cleavages and dilemmas" (p. 6).

For an example, consider the traditional subject boundaries in academic subjects, physics, chemistry, biology, mathematics, sociology and psychology. Bernstein refers to these as singulars. One could easily agree that the classification, the insulation between these knowledge categories is stronger; it is clear when one enters a physics classroom that it is hard to mistake it for another one teaching biology, for example. This is a consequence of the specialized discourses, identities and voices in each, especially in the higher grade levels. Further, we may also identify powerful agencies that do the work of boundary maintenance, as in universities and state functionaries when they erect gatekeeping assessment and decide on graduation quotas. It is also easy to see how learners can quickly adopt identities of good/bad students, and internalize insulative rules which normalize and naturalize the distinction between the different subject categories. In contrast, a more weakly classified field would be topics like technology, medicine, architecture, engineering, information

science; fields which Bernstein would term as regions. Here, the discourses are less specialized, and importantly, there is a significant amount of recontextualization of knowledge from the singulars. Concomitant to this, there are powerful agents and agencies which determine what knowledge from the singulars to be appropriated, and which singulars to draw from in the first place. In the movement from singulars to regions:

> The classification has become weaker and we shall see that, as the classification becomes weaker, we must have an understanding of the recontextualising principles which construct the new discourses and the ideological bias that underlies any such recontextualising. Every time a discourse moves, there is space for ideology to play. New power relations develop between regions and singulars as they compete for resources and influence. (p. 9)

As for framing, Bernstein describes it as the microscopic interactional regulative criteria for determining if and when one is using the approved discourses:

> As an approximate definition, framing refers to the controls on communications in local, interactional pedagogic relations: between parents/children, teacher/pupil, social worker/client, etc. If the principle of classification provides us with our voice and the means of its recognition, then the principle of framing is the means of acquiring the legitimate message. Thus, classification establishes voice, and framing establishes the message; and they can vary independently. There is more than one message for carrying any one voice. Different modalities of communication can establish the same voice. Different modalities of framing can relay the same voice (identity). (p. 12)

While classification provides the boundaries and limits for the discourse, framing determines the "form of realization of the discourse [...] how meanings are to be put together, the form by which they are to be made public, and the nature of the social relationships that go along with it" (p. 12). Framing is said to be describe the nature of the control over the (i) selection of the communication; (ii) its sequencing; (iii) its pacing; (iv) the criteria; and (v) the control over the social base which makes this transmission possible. The first four terms are elements which determine the instructional order of the discourse, while the last term determines the social order. While it is intu-

itive that in more strongly framed pedagogic interactions, the transmitter has explicit control over the five variables, in more weakly framed interactions it is the acquirer that has more apparent control.

Thus, making use of this, we may be easily distinguish between the pedagogical interactions in the contexts of a typical classroom and of a dinner table conversation: With explicit criteria and control almost unilaterally located in the hands of teachers, the classroom context constitutes a more strongly framed pedagogical situation. Bernstein also used the term 'visible pedagogy' to refer to these kinds of more strongly framed contexts. On the other hand, middle class dinner-time conversation with parents talking to their children constitutes a more weakly framed context, with invisible pedagogy—children may appear to be able to set the agenda for discussion, but it is ultimately the parents who decide to what extent certain threads may be pursued, and when the conversation has moved into an out-of-bounds domain.

We can make use of this concept of classification and framing as theoretical elements to describe the modalities of the pedagogic communication. Classification of knowledge types and framing of the pedagogical context may be placed together in two dimensions to illustrate a range of pedagogies:

|  | Stronger Classification (+C) | Weaker Classification (-C) |
|---|---|---|
| Stronger Framing (+F) | physics lesson in school | learning a trade |
| Weaker Framing (-F) | project work in specific subject | dinnertime conversation |

Table 3.1: Classification and framing matrix: pedagogic activities for combinations of classification and framing

It is important here to underscore that these examples are merely four modalities out of a two dimensions of infinite variability, and are used here only for demonstrative purposes and should in no way be taken to mean that there are only four possible combinations of classification and framing. The principle of classification and framing are useful ideas; more strongly classified pedagogical contexts offer to learners a much simplified means of distinguishing between potentially ambiguous terminology. For example, in a physics lesson, the concept of 'work' has a precisely defined meaning, whereas the same term in dinnertime conversation could have entirely different meanings at different times, depending on the context. For children in the marginalized groups, their exposure to different 'realization rules'—rules that determine the production of legitimate discourses in particular contexts—tend to be minimal; as such more weakly framed pedagogic discourse of the type commonly associated with 'progressive' pedagogy may not be useful as they may not be aware of the correct realization rules, the rules that determine how to produce a legitimate text, and as a consequence, may not be able to produce desired texts.

It is important to note here that while the examples provided here for classification and framing are provided from an educational context, the general principle of classification and framing may be applied generatively to all manner of different contexts and practices. For example, we could say that the task description for an employee in a large supermarket chain is more strongly classified and framed (+C, +F) as compared to the work required from a university research assistant (-C, -F)—for the former, her roles and responsibilities are clearly demarcated and bounded from other employees, a cashier is not expected to also restock shelves at the same time, and there are clear-cut times where she is supposed to be at work, or otherwise. On the other hand, for the research assistant, all manner of duties and responsibilities may be required of her to accomplish the

research task, and she may be required, often implicitly, to keep irregular hours in order that the project is complete. In fact, one could argue that for the supermarket employee, when she leaves her place of work, she is off duty; but for conscientious research assistants this is impossible as research issues may not be vacated from one's mind like one takes off an employee's uniform. It is important here to note that in the more weakly framed case, Bernstein was clear that the control of the context was only apparently weaker for the more weakly framed case—for the research assistant, she is still answerable to the success (or otherwise) of the research project, and there remains indirect means for her supervisor to exert control over her working conditions—the control logic has become invisible. The research assistant may not necessarily be in a more enviable working condition than the supermarket employee; weaker classification and framing of structuring principles do not necessarily connote a form of 'liberation' or 'emancipation' that allows individuals and organizations to be truly free[11].

Reconnecting these concepts with the science and environmental/social justice focus of this project, we see that changes in the school curriculum and pedagogy may encounter challenges arising from unanticipated changes in the classification and framing due to the revisions. Specifically, if environmental education perspectives become mandated inclusions into the school science curriculum, this change can represent a weakening of the classification between the sciences and the previously imagined non-sciences. Science lessons have also traditionally been more strongly framed, with set activities like laboratory investigations which often take up much of the time

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11.  Incidentally, there are numerous studies in the contemporary neo-liberal inspired governance of schools and universities which detail a form of 'steering at a distance' (Brennan, 2008; Marginson, 1997) control move—schools and universities are free to do whatever they want, as long as certain detailed objectives are met. Close study of these objectives invariably reveal that the only rational way to achieve them often involve means far more constraining than in the previous regime. Foucaultian governmentality analysts would also have much to say about this state of affairs.

budget allocated to it. To be sure, Young (2008b) specifically mentions that it was Bernstein's hypothesis "that strong boundaries between knowledge domains and between school and nonschool knowledge play a critical role in establishing learner identities and are a key condition for learners to progress" (p. 16). In the context of my research, if environmental and social justice related activities modify the framing (for example) such that more 'invisible pedagogies' become part of the science classrooms, formerly high achieving science students may inexplicably find themselves unprepared and not do as well with the revisions. Conversely, a parallel question that arises is whether, in the first place, environmental and social justice interests can find a way to fit into the traditionally more strongly framed science pedagogy that teachers may be accustomed to delivering.

### 3.4.4       *Summary and implications–Basil Bernstein*

If Young's use of Durkheimian theories of the sacred and the profane can be said to provide a foundation for curriculum theory, then the principles and conceptual vocabulary of Bernstein offer us a means to think about pedagogy, or, using his terminology, the internal workings of institutions that serve as relays for power in societies. This point should not be downplayed; without Bernstein's theories, we had very little conceptualization of how is it that curriculum influences social relations, and conversely, how social forces influence the implementation of curriculum. To summarize, elements of Bernstein's conceptual vocabulary were introduced. I started with the potential discursive gap between the world of material objects and abstract signifieds to the domain of the word and other non-linguistic signifiers, and Bernstein's understanding of the role of power in the process of assigning meaning and controlling the signification process[12]. An important consequence of this potential discursive gap is the requirement that there be legitimated recontextual-

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12.   I am using the language of social semiotics because I think that there are quite many parallels here.

izations, by legitimated individuals and organizations approved by powerful agencies who 'hold the reins', so to speak, of the discursive gap. Bernstein distinguished between the Pedagogic Recontextualization Field (PRF) and Official Recontextualization Field as two arenas where knowledge recontextualization occurs, managed by distinct actors with specific interests and motivations.

Next, I introduced Bernstein's typology of discourse and knowledge types, beginning with a basic distinction between horizontal and vertical discourses, as theoretically derived categories with roots in our common sense notions of a distinction between everyday, localized, highly context-bound discourse, and discourse for which the referents and meanings build upon specialized meanings to deal with messages that transcend the local context. Within the realm of vertical discourse, Bernstein further distinguished between horizontal and hierarchical knowledge structures. With the horizontal, epitomized by knowledges forms such as the humanities, social sciences and mathematics, the key characteristic lies in the manner in which specialized languages of analysis and discourse are developed within silos that are not inter-related to one another in terms of theoretical interest. Conversely, hierarchical knowledges refer to knowledges like the natural sciences, where an ever increasing level of abstraction integrates and assimilates prior knowledges into its explanatory régime.

Lastly, I reviewed Bernstein's concept of classification and framing, as two concepts which have been used by many other researchers to describe, among other things, classroom discourse and knowledge forms in use, educational development research, science teaching practice, and the textual construction of PISA test items (see, e.g., Hatzinikita, Dimopoulos, & Christidou, 2008; Hoadley, 2008; Maeng & Kim, 2011; Sriprakash, 2011). While classification is used to describe the degree of insulation and boundary maintenance between knowledge structures; framing refers

to the implementation of rules, norms, and regulative criteria which determine when the approved discourses are being used. If classification can be considered a means of thinking about what power does, framing may be thought of as how power does its job. Classification and framing can be discriminated by its degree, stronger or weaker, and various combinations refer to different possibilities of pedagogic discourse as shown in the table above.

Bernstein's work offers innovative new ways to conceptualize the study of environmental education and social justice perspectives in science education. Working with Bernstein's theory allows researchers alternative approaches to think about where power asserts itself in institutions such as schooling. Where previous studies have largely focussed attentions on the outcomes of the system very much in the style of black boxes, Bernstein's theories allow us to uncover the internal workings of the black box. Specifically, the role of power in the curriculum has often been undertheorized or taken as a given, manipulable based on the specific demands extant in the sociocultural context. However, Bernstein has given us a way to think of how knowledge may have obligatory power. That is to say, for example, the way physics is taught in high school is not necessarily only determined by its gate-keeping function, but it is also the result of the way the knowledge is organized.

Now, considering the insertion of environmental education and social justice themes in schooling, the pessimistic overtones contained in perspectives like Stevenson's gap and others who blame various aspects of schooling for the lack of change may be mistaken. Bernstein's theories give us a way to see how, it is perhaps not a lack of preparation, resources, administrative support, or motivation on the part of teachers and students that influence the implementation of curriculum change. Instead, it is the nature of knowledge itself that causes schooling to persist in

the way it does. To expand on this, consider the insertion of environmental education discourses in science education. If researchers are to be taken seriously and we should consider an action competence approach to the teaching of localized environmental education perspectives, then part of the task of environmental education will be the study of sociological knowledge in order to understand the social precedents to (local) environmental issues. Here, the understanding is that we need sophisticated knowledges if we desire more than mere pedestrian understanding of environmental issues, especially if such issues are so important and so urgent to all societies. In this case then, teachers will have to introduce segments of horizontal knowledge and horizontal discourse to vertical discourse and hierarchical knowledges, something that Bernstein has explicitly suggested to be potentially unproductive. If the focus of a lesson is on the localized, tacit and immediate knowledges, then this will likely be at the expense of the development of generalizable, context-independent knowledges. Insertion of environmental discourse into science education may also weaken the framing, as when teachers begin to step back from authoritative stances on issues where controversial positions exist. There may be consequences for learners who either do not agree with their teacher's position, or who fail to acquire the implicit position advocated.

Through the use of these theoretical perspectives, it is important that I am not interpreted as advocating a fundamentally conservative agenda. There are significant reasons for the inclusion of a strong environmental education agenda in schools, for one, because there are good reasons to believe that the knowledge espoused by environmental groups bear a high correspondence to the reality of the degraded environment due ultimately by human activity. However, we may need to stop considering school as a infinitely pliable and amenable to the whole range of possible mes-

sages that humanity may find itself in need of communicating to its young, liberatory or positive the message may be in its construction or intent.

## 5.    Legitimation code theory

While the philosophical perspectives of social realism as surmised by Moore, Muller, Young and others form the basis of arguments for an alternative worldview from the currently dominant social constructivism and constructionism, there is a sense here that these concepts still exist quite a distance from empirical phenomena. For example, while Young refers to his concept of powerful knowledges, describing its characteristics and its relation to other forms of knowledge, he does not offer theoretical means for describing the underlying relationships (if any) that determine whether a knowledge proposition may be counted as powerful or otherwise. Such a state poses a risk for the creation and maintenance of the logical fallacy that has been dubbed the *No True Scotsman* fallacy[13] (Flew, 1975). While the work of Bernstein progresses toward an excavation of the concept of knowledge by distinguishing between knowledge forms, this theory appears somewhat incomplete, as I will show below using the concepts developed by Karl Maton, the aggregate concept which he terms Legitimation Code Theory (LCT).

Briefly, Legitimation Code Theory is a sociological theory derived from a careful combination of principles and concepts derived from Basil Bernstein and Pierre Bourdieu. At its most general, it seeks to understand and create explanations for the ways in which individuals obtain and secure positions of legitimacy in social institutions. Maton (Maton, 2011a) describes the LCT explicatory

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13.   From the book: Imagine Hamish McDonald, a Scotsman, sitting down with his Glasgow Morning Herald and seeing an article about how the "Brighton Sex Maniac Strikes Again." Hamish is shocked and declares that "No Scotsman would do such a thing." The next day he sits down to read his Glasgow Morning Herald again and this time finds an article about an Aberdeen man whose brutal actions make the Brighton sex maniac seem almost gentlemanly. This fact shows that Hamish was wrong in his opinion but is he going to admit this? Not likely. This time he says, "No true Scotsman would do such a thing."

mechanism by analogy to a multifunction medical diagnostic instrument, for which a variety of tests may be run—X-rays, bone mineral density, NMR scanning, etc. In the LCT framework, these equivalent diagnostic instruments are specialization, semantics, and autonomy. While these theories are still currently in a state development, the domain of specialization (Maton, 2000a; Maton, 2000b) has been the most well developed and used to date. Only very crudely as a means to summarize and provide an easy entry point to understanding this theory, the arguments in the sociology of knowledge reviewed above could be understood using the LCT domain of specialization as a rivalry between proponents of knowledge and knower structures (Maton, 2007): while the 'New Sociologists' of the 1970s and related movements relied on the primacy of the identities of knowers for epistemic privilege (the truth of oppression is more accurate if spoken by the oppressed, be it on grounds of class, race, or gender), the more recent work surveyed here have researchers claiming the importance of knowledge and its associated obligatory qualities. Using the LCT domain of specialization in education, Chen *et. al.* (2010) have shown how international students at a university experience a code clash, coming from home learning environments which privileged knowledge, while the host educational culture favoured and assessed for knower attributes such as enthusiasm.

In the following, I intend to summarize Maton's (2011b) development of the LCT domain of semantics, which I will eventually use for the empirical portion of this study. As alluded to above, LCT (Semantics) takes as its point of departure Bernstein's development of the distinctions between knowledge forms, and also builds upon the accompanying concepts like classification and framing.

From a general perspective, Bernstein (2000) argues that in knowledge development, theoretical concepts possess two major characteristics that define its explanatory utility. Differentiating between the internal and external "languages of description" (L1 and L2, respectively), the internal language of description relates theoretical concepts to other elements within its explicatory framework, while the external language of description relates theoretical concepts to other theoretical concepts (at large) and empirical phenomena. In his words: "Internal languages are the condition for constructing invisibles, external languages are the means of making those invisibles visible, in a non-circular way" (p. 133). One way that these languages have been characterized is in their verticality and grammaticality (Muller, 2007, in Maton, 2011). Here, verticality refers to a property of hierarchical knowledge structures, where increasing strength of verticality refers to an increasing ability to integrate knowledge at lower levels into ideas with higher order explicatory ability. Grammaticality refers to the ability of knowledge to generate secure reference to empirical referents; theories with strong grammaticality (e.g. the natural sciences) possess unambiguous terms for empirical phenomena, whereas theories with weak grammar (e.g. sociology) have a weaker necessary relation between empirical phenomena and its theoretical elements. For Maton (2011b), these couplets (verticality/L1, and grammaticality/L2) present a challenge in its incompleteness. For one, Maton points out that the current model presents an apparent deficit mode conceptualization in that Bernstein's model views verticality as an absent/present quality. Further, while verticality is a property of hierarchical knowledges, there does not appear to be corresponding term for horizontal knowledges. While redefining a continuum of strengths of verticality goes towards resolving this issue, the crucial issue for knowledge building and development for Maton is the opacity of these concepts—while "we are told that verticality determines the form of intellectual progress but not what it is or how it determines that progress [...] Similarly, the principles underlying L1 and L2 are

not made clear and so what makes a language of description stronger or weaker remains uncertain" (p. 64). To address these issues and extend the explicatory framework of Bernstein, Maton proposes the concepts of semantic gravity and semantic density, two terms which will become useful as I explore the data of my empirical study.

Semantic gravity (SG) refers to the degree by which theoretical descriptions are grounded or 'tied to' its empirical referents, and may be weak (SG–) or strong (SG+). When semantic gravity is strong, the meaning of particular theoretical descriptions are more highly dependent on the context of its (re)production. Semantic density (SD) refers to the degree of condensation of meanings of the symbols used for theoretical description. Again, semantic density may be weak (SD–) or strong (SD+). Weak semantic density refers to symbols which condense less meaning than symbols with stronger semantic density. For example, we could say that the equation for Newtonian motion F=d/dt(mv) condenses more meaning than its equivalent explanation written out in English. Semantic gravity and semantic density can be placed on a Cartesian plane as follows:
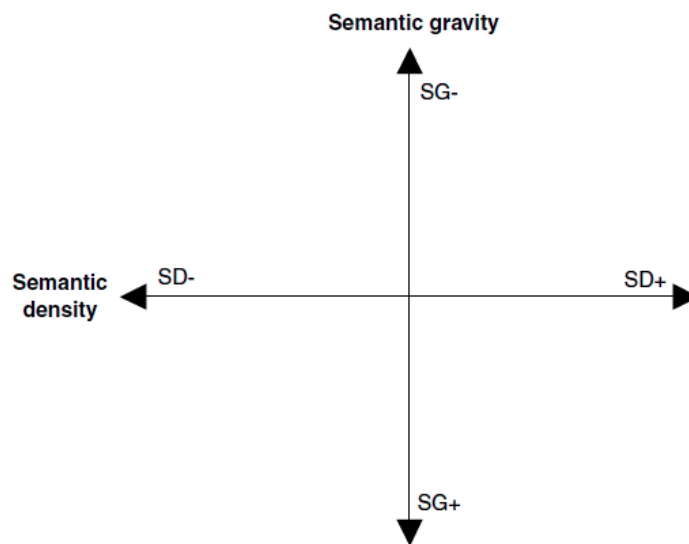


Figure 3.1: Semantic gravity and semantic density. From Maton (2011)

It is important here to note that the semantic gravity is weak on the conventionally assigned positive vertical ordinate; once again, decreasing semantic gravity indicates greater abstraction and decontextualization, and increasing semantic density means a greater condensation of meaning within symbols used for the theories. Maton disclaims the axial placement here as any indication of subjective valuing; however it is useful to think heuristically of semantic gravity as an abstraction axis, and a greater (downward) 'gravitational' pull more strongly localizes meaning to its specific empirical context.

The significance of semantic gravity and density as theoretical propositions, as alluded to earlier, are in its ability to serve as underlying structuring principles for phenomena identified and hitherto simply described into categories such as 'hierarchical' or 'horizontal'. For example, the cartesian plane allows us to see verticality as a property of knowledge forms with lower semantic gravity and higher semantic density, while grammaticality is an instantiation of knowledge forms which have higher semantic gravity and lower semantic density. In other words, for internal languages of description (L1), the language that the theories use to 'speak to itself', conceptual economy and descriptive parsimony demands that knowledge forms of SG– and SD+. Successful theories with strong verticality, that subsume large amounts of empirical phenomena and describe its interrelationships with the highest conceptual economy are of this form. For example, take the laws of motion in physics, which, when expressed mathematically, use no more than a few lines of text. From these extremely condensed symbols, we may be able to ultimately describe all forms of motion from the microscopic to the interplanetary[14]. On the other hand, for knowledges with

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14.  of course, within the limits placed by quantum effects on the microscopic level and for motion below relativistic speeds.

weaker verticality, say, sociological knowledge, these knowledges are more highly context depend-ent, and the degree of meaning condensation[15] is less than that for physics.

The concept of verticality itself becomes an instance of a specific modality on the semantic plane, increasing verticality is now conceived as a decreasing degree of semantic gravity and increas-ing amount of semantic density. In a similar way, grammaticality becomes another modality that may be expressed by a relation the semantic plane. Grammaticality is concerned with accuracy of empirical referent: here it may be seen that concepts with SG+ and SD– are optimally suited for use as a 'language of description', as means to connect theoretical propositions to empirical phe-nomena. Increasing SG and decreasing SD contextualizes knowledge and increases descriptivity of symbols used in the communication, making for a clearer description of how theories may be re-lated to empirical contexts. Considering the semantic plane, other combinations of semantic grav-ity and density are now seen as able to subsume different kinds of knowledge into this explanatory framework. For example, engineering knowledge, which, like the natural sciences, are often de-scribed in semantically dense languages, but deal with limited contexts of the form of problems that it considers (therefore the different branches of engineering). Such knowledge is not easily de-scribed by a hierarchical/horizontal knowledge distinction, but fits readily as a form of knowledge that is SG+ and SD+ on the semantic plane. Lastly, with popular culture management and psycho-logical terms, for example, *syngerism, (w)holism, abundance mentality, critical thinking*, or even *social justice*; such terms may be interpreted as being fairly context indepdenent, and condensing very little real meaning—a plausible reason why they have found widespread use the same way one uses

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15.  sociological (and other) knowledges can condense *feeling* and emotions too; but this is not under consideration here.

insulating-foam-in-a-can: simply point and spray, as the terms will adapt and fill any context with as many different interpretations as the context requires.

To summarize, the semantic plane and the concepts of semantic gravity and density allow us to conceptualize knowledge of various forms into a economical explanatory framework, which generates knowledge categories as different combinations of its two variables. This is a decided improvement over other knowledge taxonomies for which the attempt has been as futile as wanting to draw a map as large as the country—by listing categories without meaningful description of an underlying mechanism for variation, there is always the chance that some knowledge will not have been subsumed under the taxonomy. Further, as the semantic plane is composed of two terms which, according to Maton (2011a), have infinite capacities for gradation, the concept of the plane places no necessary limits on the descriptive potential of the concept. While four modalities may have been identified above, there is no reason for limiting the number to four; other combinations may be possible.

While Maton writes from a knowledge building perspective at the level of individual theorists working within fields of knowledge, there are ways in which these concepts find applicability in pedagogical contexts too. For instance, Maton (2009) uses it in the context of two cases, a postgraduate master's degree course for instructional design, and the Higher School certification of New South Wales, Australia. In the design course, despite claims that the course would enable learners to acquire generalizable knowledge forms, analysis of student responses to assessment items reveal that students' work were primarily categorized as possessing strong semantic gravity—their written products were rooted in specific contexts used in the case-based pedagogical strategies of the instruction. Because the constructivist-inspired 'authentic learning' instructional strategy

privileged personal experiences, the projection of self into specific cases under study, and diminished the status of direct instruction about the principles for abstraction, knowledge is grounded deeply in context, and the prospects for cumulative learning are reduced. Here, cumulative learning is used to describe the process where knowledge acquired builds upon prior learning, as distinct from segmental learning, where learning is confined to episodic instances of unique contexts. Another accompanying issue for this case was the apparent setting up of students for underachievement as this pedagogic approach is in direct contrast with assessment criteria that rewards ability to generalize and theorize. This latter contradiction also forms the key inconsistency with the second case studied. In this, the learning objective of the New South Wales English curriculum was based on the metaphor of the 'The Journey', ostensibly directed toward the fulfilment of cumulative learning goals. However, official documentation elaborating assessment criteria was not helpful in detailing the its requirements; when model student work was analyzed, it was instead revealed that the assessment questions could easily be misinterpreted as requiring a personal and subjective response whereas what was desired was a direct opposite, a form that demonstrated weak semantic gravity, not weighted down to the specific contexts of the different books used to develop the general concept.

Maton (2011) proposes that for theory building, what is of importance is not so much the specific location of the form of knowledge on the SG/SD plane, but the movements in gravity and density. Maton identifies what he termed the cumulative modality, a mode of theorizing that offers the greatest potential for the growth of integrated knowledges:

> This modality offers a potential for knowledge-building because of what it does to meanings. It lifts meaning out of the gravity well of a specific context through abstracting and condensing principles underlying that context into a compact language, freeing up space in the discourse; and both 'concretizes' the analysis and 'fleshes out' con-

cepts through a dialogue with the particularities of the context. It enables both the strengthening and weakening of both semantic gravity and semantic density. This it does both between lower-order and higher-order concepts within the theory, and between theory and data. What is key here is the movements of gravity and density rather than specific states: the combination of codes enables maximum movement along the continua. The cumulative modality thus works as a kind of elevator of meaning upwards and downwards through both internal and external languages. It thereby enables the recontextualization of knowledge and so the possibility of knowledge-building across different contexts and over time.

Extending these ideas to an educational perspective, it appears that good curriculum and pedagogy must serve as what may be termed as an epistemic elevator, introducing learners to specific contexts rich in opportunities for abstraction and, crucially, deliberately moving learners 'upwards' through successive levels of weakening semantic gravity and increasing density, and 'down' again through activities directed towards learners' applying and instantiating newly learnt theory in novel contexts.

## 6.    A look back at science and environmental education

At this point, we are ready to look back at the research reviewed in science and environmental education, to consider a synthesis of ideas and to start moving forward with a plan for an empirical investigation. The first and most significant point that may be made from this juxtaposition of theories and propositions is in the examination of the curriculum proposals for signs of rhetorical strategies and positions which researchers have found to be based on faulty premises. Here, the most significant issue that afflicts all proposals for changing society by changing the curriculum and pedagogy of schooling lies in a form of what Whitty (1985) would term as the naive possibilitarianism—that changing the curriculum and pedagogy would result in a changes in the school structure and consequently, widespread changes in the the functioning of society. Once again, I do not say this to support a conservative vision for schooling, but rather with an enhanced recogni-

tion of the reasons for which schooling has managed to remain a conservative institution for most of its existence.

Next, there are critiques possible of curriculum proposals based on their missing out their theoretical blind spots. For this, I am referring to, for example, overly economistic analyses of Hodson (Hodson, 2003), Bencze (Alsop & Bencze, 2010; Bencze & Carter, 2011), which do not take into account the other dimensions where oppression and discrimination may also take place. If a case could be made with the same approach to critique as Ladwig (1996), it is exceedingly easy to point out that extant research has primarily been: (i) theoretical, in the sense that these "theories [...] are never just explanations; they always involve visions about the possibilities of something better" (Alexander, 1995), as can be said about many of the authors reviewed in the previous chapter; (ii) on small scale, ethnographic type studies, whose interpretations are most convincing to those who already are converts to the cause (Barrett, 2007; Barton & Tan, 2010; Rivera Maulucci, 2010; Roth & Barton, 2004); (iii) strong, researcher presence action-research type studies, where intervention failure is never an option (Capobianco, 2007; Steele, 2011); (iv) in the same vein as the reproduction-resistance couplet identified by Ladwig, makes use of theoretical categories which are so fundamentally elastic that all empirical possibilities fit the theoretical predictions (Craig, 2006; Hacking et al., 2007; Rogan, 2007). With similar effect, Garrard (2010) points out in a paper length article that much of environmental education research in ecocritical pedagogy is "motivated by serious moral concerns, substantiated by years of teaching experience and enlivened by a host of practical suggestions, but entirely lacks an empirical dimension" (p. 240). While Garrard draws out a lengthy critique about the use of placed based education approaches in environmental education, a sustained thread through his paper appears to be his observation that "there remains a wide-

spread, but largely untested and untheorised assumption that education about the environment (nature writing, ecopoetry and environmental literature) delivered through the environment (place-based education) will automatically be education for the environment" (p. 241).

Continuing to work with Ladwig's critique, it is clear that considering researchers' rhetorical strategies, in their choice of depiction of science in dystopian terms, there is at least an implicit appeal to paint 'mainstream' science education as oppressive and working in support of sinister conspiracies between evil corporate interests and hapless scientists; read, for example, the depictions used by Roth and Barton (2004) of contemporary scientific developments, of which they highlight "genetically modified organisms", "nuclear arms", "drugs" (pp. 2-3). Similarly, in choosing to discuss science in the context of unfettered economic globalization and its associated dismal future, Hodson (2003, pp. 651-653) demonstrates his attachment to a notion of science education in the service of capital, which is by connection to conventional Marxist style economistic critique, assumed to be unjust and oppressive. Further, in utilizing Fritjof Capra's (1982) prescription of the 'ecological perspective' to the problem of how conventional reality may no longer be adequately described via the Cartesian/mechanistic world view, we read a rhetorical appeal to close off a deprecated framework for understanding, in preference for a newer, incommensurate paradigm.

Again, I do not wish to express too strong a critique. At some fundamental level, I do not disagree with some of these bleak observations. But an argument of this form essentially misrepresents science and the telos of science education, erecting instead a straw man version too easy to knock down. For instance, consider the scientific and technological advancements required for the implementation of the Internet, the importance of which has been underscored by the recent United Nations Report proposing that Internet access be declared a human right, especially in the

light of the 2011 Middle-East 'Arab Spring' revolutions (La Rue, 2011). Ultimately, these revolutions were aided by the 'evil' corporations that provided information services like Twitter and Facebook; video sharing and web-logging sites like youtube and wordpress, again, run by corporate interests. These latter channels enabled more honest and accurate reporting provided by citizen journalists who were amidst the action, and served to broadcast a viewpoint distinct from the conventional news organizations. The concern here, just as for the radical sociologists of school knowledge, is with the potential for marginalization of the radical perspective in science education, and an interest in moving forward with the popularization of these perspectives.

More seriously however, are the implications of these theories that I review in this chapter for the proponents of new curricula based on constructivist/constructionist view of knowledge, truth, and the school curriculum. In a nutshell, constructionist ideas rooted in relativist philosophy may have given solace for researchers looking for a way out of the problem of asymmetry. First framed by Gellner (Gellner, 1992, in Moore, 2007), cognitive asymmetry referred to realization that if ideas belonged in minds, and that if some ideas were better than others, then some people were better than others. Constructionism, by adopting a fundamentally relativist position, might have provided an eminently reasonable position that all truth claims were of equal value, and therefore that all individuals were equal. As I have hoped to show of a fairly detailed review of the philosophical project of Young, Moore, Muller, and others, this position is fundamentally in error. There are truth claims which are of superior value to others, and there are ways to distinguish one from another. Some knowledges should be known to all regardless of its apparent utility in localized contexts of time and space, as one of the key features of powerful knowledges is that it enables individuals to imagine means to transcend the local. Put in other words, while proposals like

Roth's (Roth, 2010; Roth & Désautels, 2002b) in science education and place-based (Orr, 2004) and action-competence (Jensen & Schnack, 2006; Mogensen & Schnack, 2010) approaches in environmental education may result in the immediate effects in the local, learners may be dealt a disservice in the long term if the knowledges used in those context are limited. And, if Bernstein is right and segments of horizontal discourse inserted into vertical discourse have limited effectiveness or are counterproductive, then there are significant reconceptualizing work that needs to be done.

With Young's conceptualization of powerful knowledges then, we have a suitable response to researchers who claim that the 'old science' needs significant pruning, that there is little need to learn about something unless knowledge is needed in an immediate sense. The argument for utility fails, because we can never predict what knowledges our learners need in their future lives, not only that, without powerful knowledges, we would have a vastly impoverished sense of the possible, reduced access to powerful means of thinking, talking, and arguing about issues related to the issues that affect us even here and now. From a pedagogical standpoint, the concept of the epistemological elevator provides us a means to describe good teaching designed for cumulative learning.

Finally, another disclaimer: I do not present these perspectives with a mind to reject and dismiss the findings of research that has been done. Rather, I believe there are grounds for questioning the imposition of a general principle that education should be narrowly context bound. As a pedagogical principle, there may be some grounds to support contextualization of abstract ideas to the local and everyday; certainly most abstract ideas have their roots in the pragmatic, everyday knowledges. However, it is yet another thing to insist that there is no learning unless some form of

change in society occurs as a result of the learning. As a curriculum principle, contextualization is potentially disastrous; for one, not all school contexts will possess a full enough range of scenarios to offer learners a sufficiently wide base for educational experiences. As for science, it bears repeating that many of its ideas are sophisticated, counter-intuitive, and are highly unlikely to be developed from pragmatic contexts. How do we ensure acquisition of these knowledges then?

In the next chapter, I will introduce my empirical study that arises from a synthesis of these readings and the context of changes to the Ontario curriculum which I will also review.

# Chapter 4
# The empirical study

The aim of this chapter is to translate the theoretical arguments reviewed earlier into a form that finds applicability in an empirical context. As an overview, I will describe the Ontario context in which this study is set—environmental education has become a major recent influence to the science and technology curriculum, the result of which has been a series of recent curriculum revisions. The basic question for this research is then: what is the nature of these changes to the curriculum and pedagogy of science? In seeking answers to this question, the study will be divided into two parts. In the first part, a curriculum content analysis is used to compare the current curriculum document with its immediate predecessor, and in the second, a case study of three teachers is used to illustrate what may be some issues that arise out of attempting to teach the new curriculum. In this chapter, I will talk about the context, some general methodological concerns, and then discuss the steps taken to operationalize concepts for the study.

## 1.    Environmental education in Ontario: Describing the Official Recontextualizing Field

In Ontario, environmental education has had a long history from at least 1988 as environmental science (Puk & Behm, 2003). However, political and other influences have caused changes in educational policy. Most notably, the election of a conservative government in 1995 witnessed the launch of a "Common Sense Revolution" (CSR) (Bruno-Jofré & Hills, 2011), a series of neoliberal reforms (see, e.g., Apple, 2001; Carter, 2010; Klees, 2008; McGregor, 2009; Prudham, 2004) emulating changes made by the Thatcher and Reagan admninstrations in the 1980s. In en-

vironmental and natural resource matters, the CSR witnessed a drastic reduction of budget for provincial environmental protection agencies, and "extensive restructuring of the roles and responsibilities" of government vis-à-vis the public sector (Bradford, 2003; Winfield & Jenish, 1998). For schooling, CSR-backed reforms removed the 5th year of secondary schooling in 2003, reducing the years of schooling from 13 to 12, and limiting the number of electives students could take (Russell & Burton, 2000). A "back to basics" curriculum was also implemented, and with government "hostility to environmental concerns" (*ibid.*), the environmental science elective was removed (in 1998), and replaced by environmental education that was 'integrated' throughout the science curriculum, which Puk and Behm (2003) deem to be an inexcusable dilution of environmental education goals. Major influences on Ontario education policy also derived from a desire to make the Ontario curriculum "consistent with the Pan-Canadian Common Framework of Science Learning Outcomes K to 12, which did not include environmental science as a discreet [sic] subject" (*ibid.*). This, in turn, has been interpreted by Puk and Behm as a "slavish practice of following what other jurisdictions in the world do"—referring to the Third International Maths and Science Study, which also did not have environmental education as a subject heading.

With the re-election of a liberal government in 2003, the political environment once again became more conducive to a pro-environmental agenda, but it was not until March 2007[16] that a working group on environmental education was formed by the Ontario government to correct the "uneven, fragmented and inconsistent" (Bondar et al., 2007) implementation of environmental education practices throughout the province, and "analyze needs and research successful ap-

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16.   there were other priorities then, for example, policy documents paint the immediate post election era as turbulent and in need of stabilization. The conservative policies had caused periods of teacher strikes, lockouts and work stoppages, and a loss of faith in the schooling system.

proaches to teaching and learning about the environment in elementary and secondary schools" (*ibid.*). Headed by Canada's first woman astronaut and composing of six other members composed of: (i) a school board EcoSchools specialist; (ii) a former director of an environmental education program at a conservation centre; (iii) a university professor of an Environmental and Resource Studies program; (iv) an EcoSchools coordinator; (v) a former environmental education program director; and (vi) a French programming coordinator of the Canadian Ecology Centre. On June 1 of the same year, a 28 page publication, entitled *Shaping our schools, shaping our future*, but widely known as the Bondar Report, was put forth by the committee making specific recommendations for provincial government, the provincial ministry of education, school boards, and schools. The document begins with a definition of environmental education:

> Environmental education is education about the environment, for the environment, and in the environment that promotes an understanding of, rich and active experience in, and an appreciation for the dynamic interactions of:
>
> • The Earth's physical and biological systems
>
> • The dependency of our social and economic systems on these natural systems
>
> • The scientific and human dimensions of environmental issues
>
> • The positive and negative consequences, both intended and unintended, of the interactions between human-created and natural systems.

and continues by discussing the roles played by the stakeholders of public education. With respect to the school curriculum, the Report proposes "an integrated approach to environmental education" (p. 13), with "high visibility" for environmental education expectations and examples throughout the curriculum. The science and technology curricula, then undergoing review, was deemed as ideal candidates for making "environmental education *more visible than ever before*, at each grade, through the inclusion of topics specific to the environment" (p. 13, emphasis added). This was to be achieved by making sure that all front matter of curriculum documents contained a

message concerning the importance of environmental education in Ontario, together with compatible educational strategies.

In response to the Bondar Report, the ministry of education set forth its own policy framework in 2009 (Ontario Ministry of Education, 2009), two years after the release of the revised elementary curriculum with numerous revisions made to accommodate the recommendations of the Bondar Report[17]. Entitled *Acting Today, Shaping Tomorrow*, Agreeing that environmental education should be embedded "in all grades and in all subjects" (p. 12), the document lists several strategies to achieve the goal of having students "acquire knowledge, skills, and perspectives that foster understanding of their fundamental connections to each other, to the world around them, and to all living things". These included increasing student knowledge, modelling and teaching environmental education, and significantly "building student capacity to take action on environmental issues" (p. 15), suggesting specifically for schools that they, among other things:

- encourage action research that promotes partnerships and the innovative implementation of environmental education concepts and principles;
- create opportunities for students to address environmental issues in their homes, in their local communities, or at the global level.
- work with parents, the school council, community groups, and other education stakeholders to promote environmental awareness and foster appropriate environmentally responsible practices.
- enrich and complement students' classroom learning by organizing out-of-classroom experiences and activities (such as the naturalization of the school yard), as appropriate;

Certainly, if not strategies taken directly from the contemporary research literature regarding the role of action competence for environmental education and place based education practices, tant-

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17. Given the timing, and with a generalized familiarity with the way administrations work, it is hardly worth noting that these documents were likely to have been prepare simultaneously, by a small cadre of interested parties.

alizingly close approximations which speak volumes of the social-ameliorative intent given the usually conservative tenor of policy documents.

Another document of note published around the same time detailed the plans by the Ontario Ministry of Education to "build and energize Ontario's schools" (Ontario Ministry of Education, 2008c). Entitled *Reach Every Student*, this document, essentially a policy document defining the priorities and goals of the ministry at large for the second term of government, lists its Core Priority 1 as "High levels of student achievement". Perhaps predictably, these achievements were to be in literacy and numeracy, while science was relegated to near footnote status in the document:

> We are not ignoring the other specific areas of the curriculum, such as science, technology, or history. These subjects are taught in their own right as schools go about implementing the provincial curriculum. All subjects improve when literacy across the curriculum is a priority. (p. 11)

For a ministry policy document, this omission is perhaps understandable—after all, Canada ranked second in the OECD PISA rankings, as the document surmises; furthermore, the document is intended as a government manifesto of sorts, and thus paints with extremely broad brushstrokes. Interestingly however, and revealing of the schooling culture in Ontario, whereas science education is not a priority, arts education is listed as a 'supporting condition' for the achievement of the core priorities:

> Arts programs can connect with students in ways that other studies don't. For some students, the opportunity for this form of creative expression keeps them coming back to school. Arts education also fosters important skills, such as creativity and innovation.

It is as though the authors feel that, for the most part, students are unlikely to 'come back to school' for more science, and that creativity and innovation are not optimally encouraged through the sciences. Here, it is more than likely that such a subjective valuation of the different knowledge

domains will have an effect on the process of knowledge recontextualization as in the revisions that were underway for the science and technology curriculum. However, it is probably more meaningful to defer the discussion until the end of this document, when the results of the study may be placed alongside these observations.

To summarize this section, the Official Recontextualizing Field (ORF) in the study context is marked by a strongly liberal, and progressive social ameliorative agenda. Emboldened by a first term of government that, among other things, reduced "26 million learning days" lost to strikes, lockouts and work stoppages to zero (Ontario Ministry of Education, 2008c), it appears that they have taken the initiative to push a pro-environmental agenda throughout the province, in response to what was widely deemed as a disastrous experiment in in neo-liberal governance, at least in its consequences for schooling and environmental education (Fisher, Rubenson, Jones, & Shanahan, 2009; Martino & Rezai-Rashti, 2011).

## 2.      Formulating the research questions

Now that the metaphorical pieces are in place, it is appropriate to introduce the research questions which form the core of my empirical study. In some ways, deriving from the material reviewed in the earlier chapters, the research questions seem to suggest itself. Recall that a principal theme of the theoretical framework I reviewed has been the concern with the acquisition of powerful knowledges, specifically, that there are good reasons to justify the existence of knowledges which have a higher epistemological status. These knowledges should, as a matter of curriculum principle, be transmitted to learners in preference over other forms of knowledges. Further, the structuring of knowledge appears to present necessary conditions for its effective transmission, in

terms of its pedagogic performance. Hence, the questions that I will set out to resolve in my empirical study are as follows:

• What are the effects of the curriculum revisions on the knowledge content of the science curriculum?

  – Comparing between the current version of the elementary science and technology curriculum with its immediate predecessor, what is the nature of changes made to the curriculum?

• What are the characteristics of science pedagogy in fulfilment of these curriculum changes?

  – Considering the influence of the curriculum document on classroom pedagogy, what are the effects of teachers satisfying the curriculum expectations on the level of scientific knowledge in the classroom?

An emphasis is placed on a mainstream context as there is a concern here with the typical conditions that a curriculum review might find itself in. The intention here is to attempt a documentation of the effects of the curriculum review in the Ontario context, generally speaking. To the extent that it is possible, I have avoided enlisting participants which are likely to fall into either end of the spectrum—teachers already confident with STSE objectives in science, or teachers with potential for not coping with the demands of the new curriculum. Thus, for example, novice teachers were excluded from this study.

With these research questions and throughout this thesis, 'STSE' abbreviates the term "Relating Science and Technology to Societies and the Environment", which is used in the curriculum document as a section of the learning outcomes where environmental concerns are integrated into

the science and technology curriculum. While there is a rich research tradition (with diverse avenues of pursuance) associated with the Science, Technology, Societies, and the Environment (STSE) moniker (Pedretti & Nazir, 2011), these approaches should not be confused with the STSE expectations in the curriculum documents—the latter are primarily concerned with transmission of dispositions and values related to environmental education. A goal of this research is to document and characterize the curriculum STSE pedagogy and to consider if these episodes constitute integrated or discrete learning experiences in relation to the scientific content knowledge of the unit. Here, integration with scientific content is privileged due to the commitment to the philosophical foundations reviewed in the previous chapter—if Bernstein's classification of knowledge types is correct and science has a hierarchical knowledge structure with a small number of theoretical propositions explaining a large amount of empirical phenomena, it would be desirable for learning expectations to be tightly integrated within a hierarchical order—in other words, STSE learning objectives should be posed as empirical instantiations of abstract theoretical principles in order to serve as instances for deductive exemplification of general principles, or as 'data points' from which general principles may be inductively generated. In any case, strong relations should exist between STSE and scientific content expectations. Throughout this dissertation, I will refer to the "older curriculum document" and the "newer curriculum document". These refer, respectively, to the Ontario elementary science and technology curriculum documents, from 1998 (Ontario Ministry of Education and Training, 1998), and 2007 (Ontario Ministry of Education, 2007).

The curriculum, in virtually prescribing the selection, sequencing and pacing of knowledge delivery to students, sets limits and affords teachers opportunities for certain combinations of knowledge and not any other. Because this most recent curriculum revision is widely known to be influ-

enced by the desire to integrate more environmental education outcomes, it becomes an interesting study to consider how the curriculum documents have been modified to accommodate these interests. Hence, an important first step for this study is a careful consideration of the curriculum documents. Here, there will only be a limited effort in studying the curriculum documents for the elementary grades (1 through 8). This is done because these first eight grades represent the compulsory exposure to science that all students undergoing public education are obligated to pass through; for the upper grades students have a choice to undertake courses in applied or academic sciences (grades 9 and 10), or college or university preparatory courses (11 and 12). As the upper grades present science as their traditional content strands (physics/chemistry/biology) and are preparatory courses for admission into higher institutions, a smaller degree of variability in content expectations is expected. Significantly, reducing the scope to only the eight elementary grades cuts down on the volume of data analysis and demands on the presentation and visualization of data, while still maintaining a study of 75% of the state mandated K-12 standards.

While it would be useful to perform a comparative study of classroom pedagogy before and after the revision, such a study is not feasible as all teachers are supposed to have implemented the new curriculum before the time when data was collected for this project. As such, the research objective here is limited to characterizing pedagogy and collecting teacher perspectives on the revision. The objective of the classroom pedagogy research question is to characterize the way in which STSE learning objectives are delivered in the classroom, specifically from the perspective of knowledge forms—in classroom contexts, what form does STSE knowledge take; do teachers deliver STSE knowledge as discrete, unconnected pieces of knowledge, or are there larger organizational structures into which STSE knowledge claims fit? Related to the central concern of STSE pedagogy

are these other questions: What is the relation between STSE knowledge claims and the scientific content—are they taught as independent but only tangentially related knowledges, or are they merged in some meaningful way? As researchers advocate, more and better socially relevant actions are required for environmental education; in mainstream contexts, what are the prospects for such kinds of pedagogy? Given exposure to research perspectives that privilege socio-political action as central organizing activity for science pedagogy, are teachers able to translate these perspectives into mainstream classrooms?

In the next section, I shall discuss some of the general methodological considerations stemming from an allegiance to social realism.

## 3. Methodological considerations

For educational research, there has been a sense of the relaxing of the constitutive rules of the game[18]; as may be seen in the methodological debates that have raged on for decades (Denzin & Lincoln, 2000). These arguments may be considered to be methodological echoes of the struggle in the sociology of education in particular and the humanities in general reviewed earlier. In their chapter opening the instructive textbook on qualitative research methods, Denzin and Lincoln trace the history of the debates, ranging from the argument between the qualitative versus quantitative approaches, to summarize seven moments of qualitative research, noting such influences as the postmodern sensibility, the ethnographic movement, to the (then) current fashion of approaches like "fictional ethnographies, ethnographic poetry, and multimedia texts" (p. 17).

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18.   as opposed to the strategic rules—Ninniluoto (1999) distinguishes between these as the rules that determine legitimate moves (constitutive rules) versus the rules that determine the optimum means of attaining ends (strategic rules). In chess, for example, the constitutive rules determine which moves are allowed or forbidden, while the strategic rules tell us how to make moves to attack, defend, build strong positions, or defeat opponents.

My point here in reviewing the debates over qualitative research is to acknowledge its contributions to the redefinition of the constitutive rules for educational research. Certainly, there is a sense here that the opening up of alternative methods allow for a wider palette of possibilities for obtaining truth claims about reality. However, these complementary and alternative methods do not exist without criticism. In a recent book chapter, Hammersley (2011) notes that 'objectivity' has experienced a period of sharp critique after a period of influence in the second quarter of the twentieth century. Considering the candidates for the supplantation of objectivity as a goal for research, he dismissed the perspectival approach of standpoint theories, theories that assert epistemic privilege on behalf of oppressed groups, and other 'relativistic' or 'postmodern' approaches. Similar to the arguments presented here in an earlier chapter, Hammersley posits that these alternative methods collapse on their reliance on a complete rejection of objectivity on the basis of the inevitable nature of bias in social research. Hammersley proposes instead a redefinition of objectivity:

> I have argued that we should think of objectivity as an epistemic virtue that is designed to counter one particular source of potential error: that derive from preferences and preconceptions associated with commitments that are external to the task of knowledge production [...] Objectivism was wrong to treat the preconceptions deriving from external roles as simply a source of error, and therefore needing to be suppressed or eliminated: they can stimulate, and even be essential resources in reaching, true answers to factual questions. However, they *can* also be a source of error, and objectivity as an epistemic virtue is concerned with minimising the danger that they will lead us astray in assessing the likely validity of knowledge claims. (p. 40, emphasis in original)

Hammersley's project, like social realism reviewed earlier, is to pursue a methodological 'middle ground', where bias is acknowledged as a factor that influences research, yet objectivity remains as an epistemic virtue worth pursuing.

In considering the research methods for this study, a consideration has been locating the 'middle ground'—how should research be pursued in order to recognize and control for possible

sources of error deriving from personal biases while at the same time recognizing these biases (or, personal characteristics) as essential resources in reaching true answers to factual questions? Here, it is probably appropriate to reveal aspects of my personal experience as an educator as these characteristics deeply influence the kinds of phenomena that will be 'seen' in the classroom. Prior to this research, I have been a research associate in educational research projects, and before research, I have been a physics teacher at a Junior College (Grades 11-12 equivalent). These experiences were acquired in Singapore, where I grew up in, and certainly have coloured my interpretations of what counts as legitimate schooling experiences, for example. In this sense, there is some risk that in conducting research in a foreign culture, certain interpretations of events may not adequately reflect its 'true' nature or certain culturally-specific meanings are not understood. In my defence, a large part of the interpretive challenge fades away as my earlier classroom experiences have not been in a foreign language; I am a native English language speaker. Because I have teaching and research experience in science classrooms, I have been exposed to a wide range of teaching situations, and am aware of the affordances and limitations of various pedagogical strategies in science. Because school systems around the (English-speaking) world have very similar patterns of activity, often directly borrowing instructional strategies informed by research efforts internationally disseminated, 'culture shock' is certainly not expected, and not experienced. Still, steps were taken to reduce the potential for misinterpretation. In all three teachers' cases, there has been a deliberate 'oversampling' by my observing their classrooms prior to the sessions where data was collected. On the other hand, these personal characteristics have also become resources for obtaining "true answers to factual questions" as Hammersley writes. Because of my experiences as a science educator, I am able to extrapolate, to some extent, and infer the intentions of teachers as they conduct their classes. For example, instead of the uninitiated viewing of chaotic classroom situations as an un-

structured lack of learning, I believe it is possible to interpret instead dynamic interactions between students generating ideas, based on the discussions that are heard; to the extent that classroom cultures between Toronto and Singapore are similar, I can interpret when students are either enthusiastic and motivated, or apathetic and disinterested. These abilities were certainly useful and were used to obtain inferences from the data.

## 4.      About the self as research instrument

Because of the nature of empirical research in the humanities, the role and identity of the researcher can significantly influence, if not determine, the research approach and possibly the outcome of the study. In this regard, some readers may find it essential to learn about pertinent features about the author so as to be able to ascertain for themselves the degree of influence these features may have on the study. This section deals with these concerns. In addressing my identity as educational researcher, it should be fairly obvious by this juncture that I privilege, in the language of Legitimation Code Theory, epistemic relations over social relations. Here, LCT (Maton, 2000a) recognizes that knowledge claims always stand in relation to between knowledge and its proclaimed object of study (epistemic relation); and knowledge and its author or subject (social relation). How did this state of affairs came to be? Inasmuch as we are products of our environment, it is probably worthwhile to begin with the circumstances of my upbringing. I grew up in Singapore, which has as one of its dominant ideologies the principle of meritocracy. As a child of working class parents who have incomplete elementary education, and had little more than stuttering conversational ability in the English language, I saw for myself first hand the functioning of this principle—work hard, get one's credentials recognized, and then progress certain in the knowledge that one qualified for the job not because one was a friend of the person who made the hiring

decisions, but because one possessed expertise and competence suitable for the job at hand. As a student, I grew up with a love for science and technology in part due to the nature of the class of preferred jobs in Singapore requiring scientific training; more than one politician or business leader had been cited expressing the opinion that "engineers can always be managers, but a manager [who is not trained in science or engineering] cannot be an engineer". The dominant thought in schools was that the 'science stream' student was more highly valued: he (and it was always the masculine pronoun) could be a doctor, engineer, scientist, or choose to 'downgrade' later to become a lawyer, business manager, or accountant. On the other hand, being 'streamed' into the arts or business streams meant one's options became limited.

Perhaps more significantly, for me, and certainly many other students with similar family backgrounds, science proved to be comforting in the way in which one could be sure that there were such things as right answers, not more or less right answers depending on who was doing the judgment, as in the case of, for example, literature, where certain preferred interpretations existed. Because we were not brought up in English-speaking, middle-class households, my peers and I often found these rules and preferences for aesthetic appreciation to be somewhat foreign. In contrast, there was a sense of excitement in the mastery over the natural world; in opposition to the superstitious understandings of the order of the world that many in my parent's generation possessed, we instead grew to understand how things actually worked. Understanding meant that technological innovations were not magic, but simply clever applications of scientific principles; consequently one could accurately discern the value of particular ideas and products because one was better placed[19] to know whether or not it advanced the state of the art. Chancing upon a new scen-

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19.  than someone who had no expertise in the field

ario with novel elements, one could make use of the hypothetico-deductive process learnt during science class to tease out the function, mechanism, and working principles of these systems. Science was powerful knowledge, and conferred upon us power not just in control over our surroundings (and consequently, our lives), but also provided methods for acquiring more and better knowledge about our world. One could say that there was a fair degree of scientism; to qualify this however, I would borrow from Collins and Evans (Collins & Evans, 2007) who distinguish between the following:

- *Scientisml*: An overpedantic cleaving to some canonical model of scientific method or reasoning.

- *Scientism2*: Scientific fundamentalism: a zealot-like view that the only sound answer to any question is to be found in science or scientific method.

- *Scientism3*: The view that narrowly framed "propositional questions" posed by scientific experts are the only legitimate way to approach a debate concerned with science and technology in the public domain; this goes along with blindness to the political embedded ness of such questions.

- *Scientism4*: The view that science should be treated not just as a resource, but as a central element of our culture. (p. 10)

Collins and Evans also assert that their position is that of scientism4, a position which I heartily share.

To date, with graduate courses in the nature of scientific and other forms of knowledges, and other readings which report on the advances in the cultural studies of science education, there has been an expansion of understanding of issues of ontology and epistemology. I now acknowledge that knowledge claims which are the basis and foundation of the social contract in societies are far more tentative than they are often made out to be. For example, Foucault (Foucault, 1977; Foucault, 1978; Scheurich & McKenzie, 2005) shows us how we become schooled into disciplining our selves into normative positions, and how some ideas and positions become unquestionable in

societies. Overall, however, given the direction this project has taken, it should be fairly clear that at least in ambition, the goal here has to produce knowledge that reduces the reliance of relativistic or perspectival knowledge claims; for example, I do not attempt to narrate the challenges faced by science teachers attempting to teach environmental education for the first time, nor is this research particularly concerned with the teachers' ideas about the state of the environment, or some other equally valid and useful research. To conclude this section, while I acknowledge that one's personality and early upbringing probably accounts for certain choices of research direction and method, I would still advance the social realist notion that certain knowledge claims can be said to be demonstrably superior to others by means of a greater correspondence to a presumed existent reality independent of knowers. This is not to say that the work that follows is necessarily superior to other research questions and approaches, but that this research is driven with these considerations in mind.

## 5.    Choice of method

For the analysis of curriculum, a content analysis will be conducted. As there is a research concern here with distinguishing levels of meaning, an a priori coding scheme will be developed, based on the Legitmation Code Theory dimension of semantics. This coding scheme will be described in detail in a following section. Within the finite resources afforded by my position as a graduate student, such an approach is obviously out of the question. Instead, for reasons beyond the pragmatic, a case study method will be undertaken, as I will outline here. In deciding to make use of case study methods, I draw from the work of Stake (2005). In terms used by Stake, the effort here is directed toward the performance of an instrumental case study, in that the cases are used to

"provide insight into an issue or to redraw a generalization" (Stake, 2005, p. 445). Additionally,

Yin (2003) offers a rationale for the use of case studies; case study:

> • copes with the technically distinctive situation in which there will be many more variables of interest than data points; and as one result
>
> • relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
>
> • benefits from the prior development of theoretical propositions to guide data collection and analysis. (Yin, 2003, p. 18)

Certainly, this study presents itself as well characterized by these criteria; teaching performances are influenced by a wide constellation of variables, and continually adapts its pedagogical strategies to that which appeal to different cohorts of students. There certainly is no linear correlational or even cause-and-effect relation that is being established between discrete variables where control of non essential elements of the study may be accomplished. Significantly, a large part of this study is directed by the development of theoretical propositions, considering the entire range of issues from microscopic interactions in classroom contexts to the effects of these interactions in the larger social environment.

As a model of this form of theorizing and empirical research, I draw upon the work of Erickson (2004), in which he connected the theoretical and sociological breadth of understanding with the intimacy of thick description of a particular circumstance. Here, for instance, he performed detailed analysis of discourse in a classroom context where a child of migrant parents was struggling with turn taking in an English lesson. Losing her turn to speak to 'turn sharks'[20], she instead tried to restate her response but by then, the situation had turned against her favour and her speaking

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20. especially enthusiastic students who 'steal' turns to respond to the teacher to acquire the approval of significant adults. This happens mostly in the lower elementary grades.

out became out of turn and borderline disruptive to classroom talk. Erickson ultimately connected this occurrence to discourse theories and social control generally. While the exact theories and cases used in Erickson's work are not relevant here, it remains that the case study approach is suited to the mode of theorizing which interrelates the microscopic occurrences as instantiations of general theoretical principles so as to make inferences about theoretical propositions in general.

In defending the generalizability criterion often used to discredit small scale and qualitative investigations, Yin (2009) points out that generalizability ought to considered as two distinct forms. In the first, statistical generalizability, there exist mathematically sound methods for the establishment of the applicability of a proposition to the universal population from an empirical study conducted with a subpopulation sample. A second form of generalizability more compatible with case study is what Yin terms as analytic generalization, "in which a previously developed theory is used as a template with which to compare the empirical results of the case study" (p. 38). Diagrammatically, Yin's model is shown below:
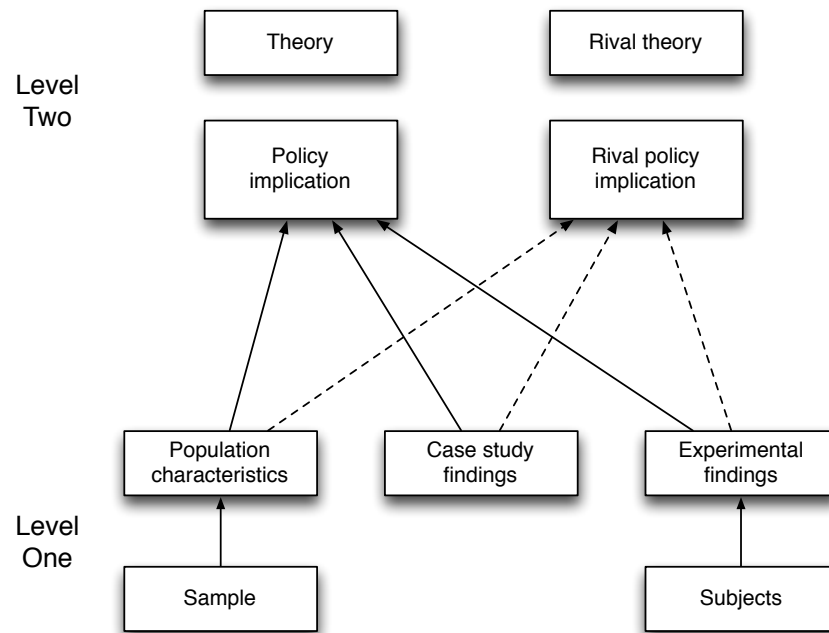
Figure 4.1: Two level generalizability model. From Yin (2009)

Here, the arrows refer to the direction of 'inferential chains'; on the left, a statistical sample of the population may be used to infer characteristics of the population, and therefore, make implications for policy/theory, either the main policy (solid line), or the rival policy (dashed line). While statistical generalization (Level 1) allows population characteristics to be inferred from sample characteristics, it is analytical generalization (Level 2) which is concerned with the translation of empirical findings to implications for theory and policy. In other words, this process may be interpreted as adjudicating between rival theories on the basis of critical empirical differences which are then observed. For instance, in mathematics, a proof by contradiction only requires the existence of a solitary counter-example to the theoretically predicted outcome. Alternately, case studies provide an excellent means of instantiating and concretizing theoretically determined elements; for example, Yin highlights three studies, two of which concerned with the demonstration of theoretical

concepts of social stratification and urban planning theory, and a third which caused a rethink in theories concerning neighbourhood crime and the strength of social networks (p. 44). Put rather crudely, the research intent here is directly concerned with the logic of demonstration: in order to show the truthlikeness, plausibility, verisimilitude, and explanatory power of one theory in preference of another, a case study is one means to instantiate, demonstrate, flesh out the empirical dimensions of the issue at hand. In the process, empirical information should 'speak back' to theory, modifying it as situations arise that deviate significantly from theoretical prediction.

## 6.    Case selection

A significant decision for case studies is in the selection of cases. Because of the role that cases play in the adjudication between, and instantiation of, theories and their theoretical predictions, cases need to be carefully selected to maximize the ability of the cases to perform in its desired roles. For this study, as previously mentioned, teachers who were representative of a typical mainstream context were chosen. In part due to pragmatic circumstances, and in part because it would present a more credible challenge to existing theory regarding the imposition of STSE learning objectives in science classrooms, participants were selected from within a group of teachers who attended a professional learning community (PLC). This PLC consisted of four full-day sessions over four months, where teachers were tasked to develop, implement and present new curriculum explicitly directed toward the fulfilment of the new curriculum objectives. While the details of these sessions will be detailed later, it is enough here to mention that such an intervention is unusual for in-service teachers, most of whom will proceed to implement curriculum changes without prior training, or, at best, a short term training session unlike the length of the PLC these participants attended. From the PLC, I managed to obtain two volunteers. A third participant was admitted

into the study despite her non-attendance in the PLC because she was a part time Master's in Education student and had attended a course discussing STSE issues in the science classroom.

These three participants, Alice, Bob and Clara (pseudonyms) were teaching at the grade 4, 7, and 11 levels respectively. In addition, Alice was teaching a unit on ecology, Bob was teaching about heat, and Clara taught a university track course in chemistry. All three teachers taught in schools in urban settings; Alice and Clara taught in schools located in neighbourhoods with a high proportion of visible minorities. According to Clara, it would be fair to characterize the community as low-income. Conversely, although Bob also taught in a school with high proportion of visible minorities, these were migrants who tended to be in the high-skill and professional vocations, and as such, many of his students were motivated and well on their way to being high academic achievers.

Considering the affordances of these cases, there is a fair sense that these teachers represent the typical profile for teachers and teaching contexts in the local community where this study is conducted—two of them female, one of them visible minority, all of them teaching in urban environments, two schools with students from working class backgrounds, one from the technical/professional class. Units in the three scientific subjects areas of physics/chemistry/biology were studied. These cases fall within the spectrum of the range of schooling contexts which constitute the norm; certainly, the only outlying characteristic of these cases was the teachers' extensive preparation for teaching the revised curriculum that has an emphasis on STSE learning objectives.

## 7. Data collection

Pedagogical data for this project was collected in the winter semester of 2010, between the months of February to May, with observations as frequently as three times a week per teacher. As

with any classroom observation, the presence of a researcher in the classroom would inevitably cause some form of interference to the classroom interactions, as such, it was deemed important to remain in the classroom for a significant period of time. The aim of these observations was to study the implementation of a particular unit as it was taught from beginning to end, so as to get the full range of pedagogical strategies employed by the teachers. These observations were carried out during the same period of time. The lesson schedules for all three schools varied—one school had different schedules for odd/even weeks, another had odd/even days, and the third had a four-day-week schedule. As such, there were no recurring scheduling conflicts such that particular lesson observations had to be compromised. However, this is not to say that conflicts did not exist, or that weather or traffic conditions precluded my ability to make the transit between schools in a timely enough fashion. Some lessons were not observed, but through communication with these teachers, most of these were sessions where activities not essential to the conceptual development were conducted (e.g. test taking, individual seatwork, school assigned administrative requirements, school festivals).

Initial interviews were scheduled with participants, to gather their views on environmental education, science education, their experiences with teaching and/or learning environmental education, and their personal histories with regard to education and schooling. This was done so as to discern their personal perspectives and also as a means to introduce myself as a researcher and guest in their classroom. Here, I draw from the perspective of Fontana and Frey (2005), when they claim that the interview is not a "one way, neutral exchange of question and answer between researcher and informant. The interview is actually a collaborative product between the two, a pastiche that is put together by fiat" (p. 696). In addition, I wanted to gather some insight into teach-

ers' lesson planning considerations, so whenever the opportunity arose, I sat with teachers and discussed with them general issues that arose through the process of lesson planning. For Alice and Bob, I did not actively suggest any pedagogical strategy, because the brief to them had been that I was to be present to observe their implementation of the STSE curriculum project that they had designed with colleagues during their participation in the PLC. In Clara's case, because she had no prior curriculum project to implement, I assisted directly in the production of lesson activities for her as a response to her requesting assistance. Details of these lessons will be discussed later.

A major source of data is in the form of recordings of teacher talk during lessons. Along with the interviews, these discourse productions were audio recorded[21]. These recordings were then imported into a transcription and analysis software Transana where selective transcription was done. This was done in several passes; in the first pass, a major task was the application of timecode indices—a software 'marker' to translate where theoretically relevant occurrences happened in the recording to a segment of the textual transcript so that the audio segment may be accessed rapidly for review. In the second pass, theoretically interesting segments were then transcribed and coded for themes generated inductively. Paradigmatic quotations were then selected for inclusion into the thesis.

In addition to interviews and audio recordings of teacher talk, field notes were collected to supplement the audio recordings. The format of these field notes have been somewhat influenced

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21. While video recordings exist as a viable means to capture non-verbal data and hence increase the data 'bandwidth' of the record, significant challenges exist which make video recoding a prohibitive proposition for this project. Firstly and pragmatically, I do not possess video equipment of sufficient quality to collect high quality data; for example, a problem exists that for cheap video recorders is that moving the camera rearwards enough to collect a complete view of the classroom scene will result in poor audio and image quality. Secondly, video data offers data that is necessarily biased by the very placement of the camera (Goodwin, 2000); also, analysis of the video record is not straightforward and is affected by the trained gaze of the researcher (Goodwin, 1994). To be sure, audio recording is certainly non-neutral and affords a limited perspective for analysis. In sum, however, audio recording was chosen in the balance between theoretical and pragmatic considerations.

by the Singapore Pedagogy Coding Scheme (Luke, Freebody, Cazden, & Lin, 2004), in which I first acquired my experiences of classroom pedagogy coding research. These notes were organized by lesson phases, or blocks/chunks of activities that define the pedagogical intention of a segment of time. For instance, teachers could be telling their students about a theoretical concepts via a lecture, followed by assigned individual seatwork and closing the lesson with a whole class discussion. This lesson constitutes three phases, and notes would be taken to record: (i) classroom seating: whether all in front as in early elementary story-telling time, or in individual seats or in pairs or groups; (ii) main phase activity: whether the activity was a lecture, an Initiate-Recall-Evaluate triadic discussion, individual seatwork, pair/group work; (iii) type of students' produced work; (iv) percentage of students on-task; and (v) some extended description of the phase, including theoretically significant observations, and notes of significant discourse elements uttered. Other materials also collected were student produced work and teacher resources used for lesson planning. The science and technology curriculum document from the Ministry of Education was also used as a data source in the analysis, as I will detail below.

## 8.     Coding scheme—curriculum content analysis

Deriving from research in mass communication, content analysis is now widely applied in many fields (Schreiber & Kimberly, 2011). While content analysis does not prescribe particular methodological approaches (e.g. quantitative/qualitative, grounded analyses), it is regarded here that an optimum method of analysis is a simplified quantitative comparison of the code frequencies occurring in the text. As such, this coding scheme is presented as a means to operationalize theoretical definitions and elaborate the *a priori* coding categories that will be used in the study.

### 4.8.1     Unit of analysis

The elementary science curriculum document is divided into lesson strands which are coherently organized segments of knowledge. For example, the elementary grades are divided into Life Systems, Matter and Materials, Energy and Control, Structures and Mechanisms, Earth and Space Systems. These strands are developed across the grade levels, and in any one year, students are expected to complete one unit from each of these themes. Each unit consists of three sets of specific expectations, in the older curriculum, entitled Understanding Basic Concepts; Developing Skills of Inquiry, Design, and Communication; and Relating Science and Technology to the World Outside of the School. The unit of analysis for this coding instrument will be the specific expectation. For example, a Grade 7 Earth and Space Systems unit on "The Earth's Crust" contains as a specific expectation for the section "Understanding Basic Concepts":

> By the end of Grade 7, students will distinguish between rocks and minerals and describe the differences in their composition (e.g. minerals, such as the mineral calcite, are components of rocks such as the sedimentary rock limestone, in which calcite is found).

Each of these sets of specific expectations consists of about 5 to 10 knowledge propositions, so that a complete unit consists of about 20-30 knowledge propositions. The unit of analysis for this coding instrument is the knowledge proposition of the specific expectation.

### 4.8.2     Coding scheme–Semantic Gravity

This coding scheme, as a first-pass attempt, is designed as a relatively coarse instrument, distinguishing only between relatively strong and relatively weak levels of semantic gravity and density. The aim of the coding is to establish the intent of the curriculum, given the best case scenario (e.g. ideal teacher, students, school environment, etc), and without concern to pragmatic concerns

which might influence the achievement, or otherwise, of these expectations. In other words, the coding is to be applied to the face-value interpretation of the exact terms used in the document.

Considering the typical terms used for the specific expectations in the curriculum, there are a few characteristic aims that make up the range of expectations. In science, one common type of curriculum expectation is a demonstrative instantiation of a general theoretical concepts, or the pointing out an empirical phenomena whose underlying explicatory mechanism is some scientific principle that is being introduced and developed. These are propositions with relatively stronger gravity (SG+) as they are firmly embedded within an obvious empirical referent. Conversely, another common aim is a form of theoretical development, a refinement of prior knowledge that may or may not be strongly connected to an empirical referent. These may take the form of, for example drawing comparisons and generalizing categories and characteristics of objects, concepts, or principles. These latter kinds of propositions are relatively weaker in semantic gravity. A table summarizing the coding criteria is as follows:

| Code | Meaning | Suggestive keywords | Examples |
|---|---|---|---|
| SG+ | relatively high context dependence, specific expectations are used in direct relation to, or refer to, empirical phenomena in a deductive manner (theory explains phenomena); expectations 'point out' what it is the theoretical concept is 'about'. | identify, recognize, compile data, communicate, design and construct, describe | "identify various types of chemical reactions, including synthesis, decomposition, single displacement, double displacement, and combustion" (Grade 11)<br><br>"recognize large-scale and local weather systems (e.g. fronts, air masses, storms)" (Grade 5) |

| | relatively low context dependence, specific expectations are directed toward theoretical development of concepts, or abstracting characteristics of empirical phenomena for further discussion | classify, distinguish, demonstrate understanding, compare, explain, interpret, investigate, predict, plan, fair test, formulate question, investigate, analyse, evaluate | "investigate the ways in which different forces (e.g. magnetism, static electricity, muscular force, gravitational force) can change the speed or direction of a moving object" (Grade 3)

"compare the structure of different plants (e.g. cactus, coniferous tree, moss) and show how their structure enables them to live in specific conditions" (Grade 8) |
|---|---|---|---|
| SG– | | | |

Table 4.1: Coding scheme for semantic gravity

Using this coding scheme, the example expectation above (distinguishing between rocks and minerals) should be coded as SG-.

### 4.8.3    Coding scheme–Semantic density

As with semantic gravity, semantic density here is used with a very coarse resolution, with only two levels, SD+ and SD-. Semantic density refers to symbolic condensation, and while for scientific content it can be fairly easy to spot terms with high semantic density, a challenge for semantic density is that for at least the elementary grade levels, the language used often avoids reference to specific terms that signal the use of semantically dense concepts. For example, a Grade 8 life systems unit on cells, tissues, organs and systems contains this specific expectation: "explain the function of selectively permeable membrane in cells". While the semantic gravity coding is clear (SG-), the semantic density coding is not quite so, and requires some background knowledge on the part of the coder. In this case, an explanation of the function of the selectively permeable membrane typically involves a discussion into the differential hydrophilic and hydrophobic properties of the different interfaces of the membrane. Such a statement should be coded SD+, due to the number

of terms, meanings, and principles which are condensed into explanation to make sense of the effect.

Another issue that occurs for coding is the grade dependency of semantic density. An idea that may be direct and straightforward for a upper grade student may actually be complicated and require some explanation when used for younger grade students. For example, for Grade 2 Life Systems—Growth and Changes in Animals, an expectation reads: "identify and describe behavioural characteristics that enable animals to survive (e.g. migration, dormancy, hibernation)". While a Grade 5 or 8 student will find the concept of behavioural characteristics direct and unproblematic, for a Grade 2 student encountering the term for the first time, this term requires much unpacking and is consequently fairly dense for the grade level at which it is being introduced. The intent of this code is not to assess an absolute semantic density throughout the entire science curricula (or the universe of possible terminologies for that matter), and to create a taxonomy of semantic density, but to indicate the relative density of terminology in use particular to the grade level. This coding has some potential to have a poor reliability for certain kinds of specific expectations.

One of the tasks that learners of science have to perform is the scientific practices of recording, summarizing, and displaying data, often in the form of graphs and other data manipulation and presentation formats. Lesson expectations of these sort are precisely a form of data reduction, and are means for students to learn about scientific methods of condensation of meaning. This class of expectations should be coded as possessing relatively high semantic density. A table summarizing the coding criteria for semantic density follows:

| Code | Meaning | Suggestive keywords | Examples |
|---|---|---|---|
| SD+ | higher degree of meaning condensation relative to grade level, terminology used contains terms and references to concepts and objects which students are unlikely to have background knowledge of. | "in quantitative terms" (mathematical terminology usually condenses more meaning), compile data, data manipulation and presentation terms, WHMIS (Workplace Hazardous Materials Information System), | "identify a variety of manufactured products made from mixtures or solutions and explain their functions" (Grade 7)<br><br>"classify organisms according to heir role in a food chain" (Grade 4)<br><br>"distinguish between kinds of motion and indicate whether the motion is caused indirectly (e.g., by gravity, static electricity, magnets) or directly (e.g., by applied force)" (Grade 3) |
| SD– | lower degree of meaning condensation relative to grade level, terminology used contains terms and references which students are likely to have good understanding and background knowledge of. | "in qualitative terms", identify properties, describe how, | "explain in qualitative terms the relationship between pressure, volume, and temperature when a liquid is compressed or heated and a gas (e.g., air) is compressed or heated." (Grade 8) (cf. $pV=nRT$ as SD+ even for gr. 11)<br><br>"demonstrate an awareness of air as a substance that surrounds us and takes up space, and whose movement we feel as wind" (Grade 2)<br><br>"describe qualitatively how visible light is refracted" (Grade 8) |

Table 4.2: Coding scheme for semantic density

Using this coding scheme, the sample expectation (distinguishing between rocks and minerals) should be coded SD+, as the terminology used in the process of discriminating between the rocks and minerals have to condense a considerable amount of meaning relative to the grade level of the learners (Grade 7).

### 4.8.4 *Coding scheme—Effect on semantic range*

What is possibly more important than the status of semantic gravity and density of learning objective is what this objective aims to do to meanings. Maton (2011) offers that for cumulative knowledge building, an important semantic manoeuvre is the successive movement up and down in the semantic range. This semantic range may be thought of, for simplicity, as combinations of

higher semantic gravity and weaker semantic density (SG+, SD-) as the lower portion of the range, and weaker semantic gravity and stronger semantic density (SG-, SD+) at the higher end of the range. Through this process of movement up and down the semantic range, meanings are successively theorized, abstracted, and generalized from their empirical referents, causing an increase in the semantic range; and then concretized, instantiated, demonstrated and exemplified in empirical phenomena, a decrease in the semantic range. Charted over time, a semantic profile for cumulative knowledge (re)production takes the form of a wave, while semantic 'flatlines' are also possible:
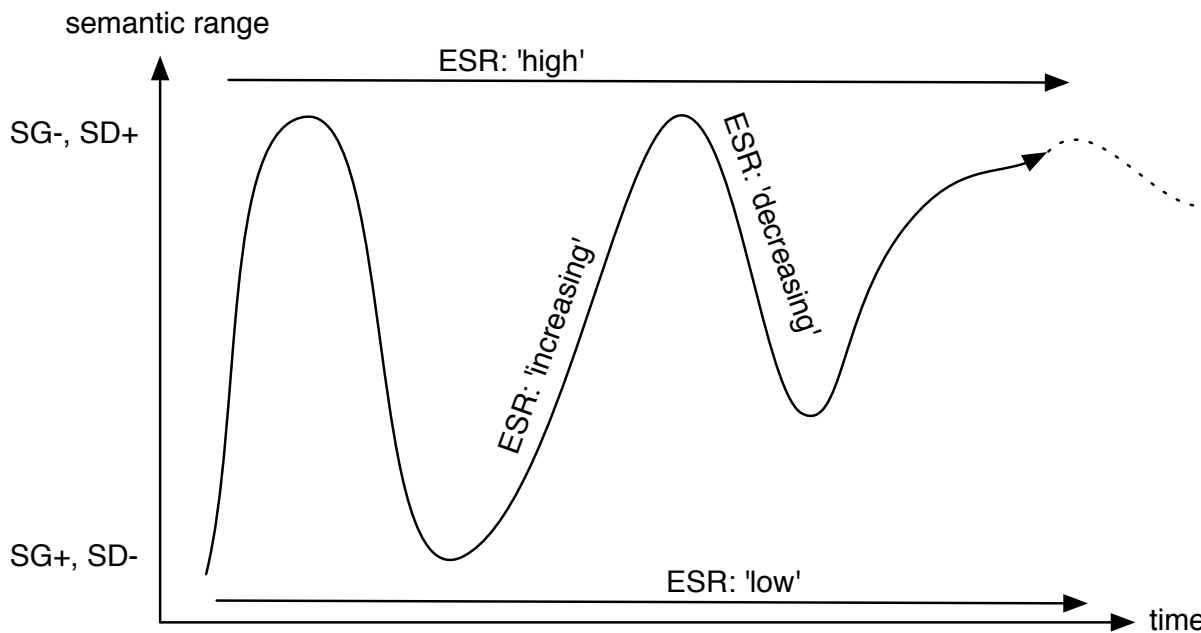
Figure 4.2: Semantic range, graphical representation of Effect on Semantic Range (ESR)

Through this coding scheme, there is an attempt here capture some sense of the movement afforded by the learning objectives of the science curriculum. Hence, the coding scheme for effect of semantic range (ESR) is presented below:

| Code | Meaning | Suggestive keywords | Examples |
|---|---|---|---|
| High | High 'flatline', no change in semantic range, meanings kept at high range by primary reference to theoretical elements with relatively infrequent reference to empirical phenomena that exemplifies general theoretical principle | theoretical problem solving, use of technical language with high semantic density, discussion of theoretical entities and postulates with little or no reference to empirical phenomena | "solve problems in related to quantities in chemical reactions by performing calculations involving percentage yield and limiting reagents" (grade 11)<br><br>"use appropriate science and technology vocabulary, including *truss*, *beam*, *ergonomics*, *shear*, and *torsion*), in oral and written communication" (Grade 7)<br><br>"State the postulates of the particle theory of matter (all matter is made up of particles; all particles are in constant motion; [...]; the particles are close together and have strong forces of attraction between them" (Grade 7) |
| Increasing | Specific expectation brings discourse and meaning up the semantic range, via an inductive process of theorization, abstraction, generalization. | classify, compare, 'patterns', distinguish | "classify a variety of animals using observable characteristics" (Grade 2)<br><br>"analyse the long-term impacts on society and the environment of human uses of energy and natural resources, and suggest ways to reduce these impacts" (Grade 5) (theorization from daily practices to 'long term' timescales)<br><br>"conduct an inquiry to identify the characteristics and properties of magnetic fields (Grade 11) |
| Decreasing | Specific expectation brings discourse and meaning down in the semantic range, via deductive process of concretizing, instantiation, demonstration, exemplification. Students learn instances of theory in different situations. | predict, plan investigations, conduct an inquiry, design and build | "investigate how objects or media refract, transmit, or absorb light (e.g. non-luminous objects are seen when reflected light enters the eye; the stars are seen when transmitted light enters the eye" (Grade 8)<br><br>"use technological problem-solving skills, and knowledge acquired from previous investigations, to design, build, and test a structure that involves interactions between liquids and solids" (Grade 2)<br><br>"identify different kinds of forces (e.g. gravity, electrostatic force, magnetic force) (Grade 3) |

| Low | Low 'flatline', no change in semantic range, meanings kept at low range by reference to description of empirical phenomena. Empirical phenomena is used to little or no effect in the development of a generalized subsuming principle, theoretical explanation, or organized, structured patterning. | identify, describe, define | "define a structure as a supporting framework with a definite size, shape and purpose, that holds a load" (Grade 3)

"assess the impacts on personal safety of devices that apply the properties of light and/or sound (e.g., UV-coated lenses in sunglasses, safety eyes on garage door openers, reflective material on clothing, ear plugs, backup signals on trucks and cars, MP3 players, cellphones), and propose ways of using these devices to make our daily activities safer" (Grade 4)

"follow established safety procedures for outdoor activities and field work (e.g., stay with a partner when exploring habitats; wash hands after exploring a habitat)" (Grade 6) |

Table 4.3: Coding scheme for Effect on Semantic Range (ESR)

Using this coding scheme, the sample expectation (distinguishing between rocks and minerals) should be coded as ESR 'increasing' as it discusses the similarities and differences between rocks and minerals (regardless of whether or not teachers have an actual empirical referent of a piece of rock—a video or a even reference to something that is common to everyday experience is sufficient), and attempts to develop a rudimentary classification scheme. Classification schemes in general are high in the semantic range, as they take in a large range of empirical phenomena and attempt to extract ideal characteristics as a form of theorization. An important distinction here to keep note of is the difference between the intention of the curriculum document, and what may be possible pedagogical procedures to achieve the learning objective—the ends-means distinction. While the intention of the curriculum document may be achieved through means with a different ESR, this code is for the curriculum document, and pedagogical approaches should not be considered. For example, in distinguishing between rocks and minerals, one common strategy might be to continually refer to a set of rocks and minerals collected in a box. This might then be coded

as ESR 'low', in contrast to the goals of curriculum document, which is to attempt generalization from empirical referents.

**9.    Coding scheme—Pedagogical analysis**

The pedagogical contexts present three cases of educators in different contexts implementing their interpretations of the revised curriculum. As a means to describe analytically the pedagogical processes occurring in these three contexts, it is important to develop a coding scheme with consistent referents so that a meaningful comparison may be made between cases, and theoretically significant aspects of these cases may be used to make meaningful inferences about the nature of science pedagogy. To that extent, a coding scheme has been developed *a priori*. This coding scheme is based on the LCT concepts of semantic gravity and density as discussed and used to code the curriculum document as above. Similar codes are used, as well as the concept of the semantic range. It is important to note here that the aim is to derive a code for the teachers' pedagogical effect from a synoptic view of the unit of analysis, (i.e. a phase, see below). There are inherent difficulties with establishing intention, so only observed effects are coded. Meanings are certainly not immune from misperception and are not necessarily stable constructs. I acknowledge that student perception of the meaning may be different than that intended by the teacher, but as no student perspectives were gathered for this research, this code applied only for teacher talk. The empirical referent for each code category is described below.

*4.9.1    Data sources*

In addition to classroom recordings, conversations and semi-structured interviews were recorded, and analyzed to draw out pertinent information and create thick descriptions for each case. Data sources for the coding of segments are derived from audio recordings of teacher talk, semi-

structured interviews, and discussions during lesson preparation sessions. The coding scheme is only applied to classroom pedagogical data. Overall, however, the audio data set consists of the following:

|       | Class recordings | Interviews | Discussions | Total |
|-------|------------------|------------|-------------|-------|
| Alice | 11               | 3          | 2           | 16    |
| Bob   | 24               | 2          | 7           | 33    |
| Clara | 23               | 2          | 12          | 36    |

Table 4.4: Audio recordings by type

### 4.9.2   *Unit of analysis*

For the classroom pedagogy, lessons were divided into phases by activity structure. These activity structures are defined as the period of time between distinct shifts in lesson activity. For example, the beginning of class marks the shift from no lesson to the start of one. The teacher may then be taking attendance; when this is done, another shift is done to a next phase, which may be a review of a previous lesson in order to set the stage for the day's lesson. Typical phase types include: (i) lecture; (ii) Initiate-Response-Evaluate (IRE) question and answer sessions, where the teacher asks questions which elicit thinking or recall; (iii) classroom administration, where the teacher provides instruction for classroom organization or an upcoming activity; (iv) group student work; (v) presentation/demonstration; (vi) individual work or research; (vii) teacher-led demonstration; and (viii) test-taking.

This choice of unit of analysis is strategic—while choosing a small unit, for example, a speaker turn, might be able to offer rich data, the analysis requirements would be excessive within the resource limitations of this project. On the other hand, while a larger unit, for example, an entire les-

son, would ease the demands of analysis, variations in code category may occur throughout the lesson which would not be recorded due to the coarseness of the unit. Other choices exist—for example, a unit of analysis based on an arbitrary (small) amount of time. Such a choice would not be adequate either because of the difficulty of harmonizing multiple codes for single units of analysis, which might occur if pedagogical activity shifts during the arbitrary time unit.

### 4.9.3    *Pedagogy coding scheme—Semantic gravity*

In consideration of the definition of semantic gravity as the context dependency of knowledge propositions, and the empirical phenomena available for coding within a unit of analysis, there is a cognizance here that semantic gravity should refer to the *knowledge content* of the phase. Supposing that pedagogical activity is concerned with the transmission, acquisition or the facilitation of learning of a specific knowledge objective, the semantic gravity code categorizes this knowledge objective in terms of its context dependency. In other words, this code is concerned with what the phase is 'about'.

| Code | Meaning | Examples |
|---|---|---|
| SG+ | Stronger context dependence, knowledge objective is based strongly on empirical phenomena either of immediate physical or conceptual proximity—physical object, or reference to a representation (e.g. a photograph, video). | classroom management (all grades); story telling time about a tree and animals which depend on it (Grade 4); video presentation about the effect of fire on forests (Grade 7); demonstration to communicate pollution of significant waterways (Grade 11). |
| SG– | Weaker context dependence, knowledge objective is based weakly on empirical phenomena, is directed toward the transmission of abstract knowledge. | concept of food web (Grade 4); concept of fair test (Grade 7); elemental periodicity (Grade 11). |

Table 4.5: Coding scheme for pedagogy—semantic gravity

There is a possibility that during a single phase, teachers may work with a range of ideas of varying semantic gravity. In such a case, the primary idea from a synoptic viewpoint is used for the coding. This procedure is justifiable as teachers are unlikely to introduce many new ideas to learners all at the same time.

### 4.9.4 *Pedagogy coding scheme—Semantic density*

Again, as with semantic gravity, semantic density refers to the symbolic condensation of the main idea that is being transmitted, discussed or in use during a phase. To elaborate:

| Code | Meaning | Examples |
|------|---------|----------|
| SD+ | Stronger symbolic condensation; ideas in use during phase condense a relatively large amount of meaning. | scenario of being stranded on an island, concepts of survival (Grade 4); Description of thermal transfer by reference to molecular motion and transfer of energy (Grade 7); concept of electronegativity (Grade 11) |
| SD– | Weaker symbolic condensation; ideas in use during phase condense a relatively small amount of meaning. | lesson instructions (all grades); group work to prepare short skit for class (Grade 4); students working on a model jacket for homeless people (Grade 7); introduction to worm composting, identifying the parts and functions of a compost heap (Grade 11). |

Table 4.6: Coding scheme for pedagogy—semantic density

### 4.9.5 *Pedagogy coding scheme—Effect on semantic range*

The effect on semantic range is perhaps the most important coding category in studying the classroom pedagogy. Here, the intention is to categorize the overall pedagogical trajectory of the phase, to discern the net influence of the activity of the phase to the meanings of the knowledge propositions in use. Generally speaking, a common pedagogical strategy is to introduce an idea that is high on the semantic range, talk about the relation of this idea with other similar ideas or its precedents, then assign students some activity to work with these ideas, finally closing the activ-

ity by talking about how the activity demonstrates the general principle. In this example, we see that the pedagogy follows a wave—the introduction (usually via a presentation, lecture, or "guess-what's-in-my-head" style IRE dialogue) is high on the semantic range, decreases with the student activity, and then is finally increased again when the teacher 'wraps up' the lesson or unit. In what follows, I will provide a fuller description of the code categories and examples from the cases studied.

| Code | Meaning | Examples |
|---|---|---|
| High | High "flatline", classroom pedagogy is primarily of lower semantic gravity and higher semantic density, and remains higher on the semantic range throughout the phase. | commonly, teacher-fronted lectures where control of knowledge transmission is explicit: scenario of being stranded on island—lecture on the metaphor of planet Earth as an island, impact of human activities on the island (Grade 4); explanation of essential features of bar graphs (Grade 7); lecture on relation of electronegativity with atomic size (Grade 11). |
| Increasing | classroom pedagogy is concerned with the development of generalizations or generalizing principles from reference to empirical phenomena. | Often a result of teacher pointing out generalizing principle towards the end of an activity or lecture. "Can you see a pattern here?"—describing tropical regions, pointing out its locations on a map to generalize the idea of tropical regions being close to the equator (Grade 4); "going over" a lab report—teacher returns student work, and summarizes principles from laboratory work done. (Grade 7); explaining the use of a *Jenga* toy set as a metaphor for ecosystem collapse as elements are removed (Grade 9). |
| Decreasing | classroom pedagogy is directed toward the development of empirical instantiation and demonstration of general principles through activities with objects or intellectual activity (alone or in groups) | Often associated with student activities that teachers assign to students. Teacher issuing instructions for activity: "Now that we learnt about protecting rainforests, you are going to do a little bit of research" (Grade 4); Practical activity—students working with 'conduct-o-meter' to compare thermal conductivity of different metals (Grade 7); Students assigned individual seatwork on elemental periodicity (Grade 11). |

| Low | Low 'flatline'; classroom pedagogy during the phase is primarily concerned with the content that is higher semantic gravity and lower semantic density throughout the phase. | Classroom management and administration. Group work preparation of short skit for class (Grade 4); Group work preparing a model jacket during class when focus is not on thermal properties, but on aesthetic function instead (Grade 7); Podcast project phase concerned with the recording and audio adjustment of the podcast (Grade 11). |
|---|---|---|

Table 4.7: Coding scheme for pedagogy—Effect on Semantic range

## 10.    Upholding standards for research

Because there are two significant approaches to this study, the quality criteria for these two approaches should be considered separately. For the curriculum coding scheme, an attempt was made to assess the reliability of the coding instrument by recruiting volunteers to test-code segments of the curriculum document. Invitations to participate were sent out to a mailing list of researchers working with Legitimation Code Theory, and also to several colleagues. A document was prepared describing the coding scheme in some detail. In the end, there were only two completed response sheets returned, both of which were submitted by colleagues not trained in LCT. In comparing the coding results, a very poor inter-rater reliability score was obtained in comparison between the three coding results. This is most likely to be attributed to a lack of exposure to the LCT concepts and insufficient training in using the scheme. Validity of this instrument was established by presenting a version to the thesis supervisor, who judged it as adequate for the purposes of the study.

As for the case study, because the theoretical framework was modified post data collection, thematic generation was conducted via an inductive theory generation approach (Charmaz, 2005; Glaser & Strauss, 1977). Following Lincoln and Guba (Lincoln & Guba, 1985, Chapter 11), the following steps were also taken to increase the credibility of this study:

(i)  prolonged engagement: pedagogical contexts were studied for a total of about fourteen weeks, covering an initial period of learning the 'culture' of the context, before a complete unit was observed. During this period, initial interviews were conducted as a form of introduction to gain the teachers' perspectives and personal histories and philosophies with regard to education and teaching, as well as a means to introduce myself and the project aims to teachers, establishing trust in the process.

(ii) retrospective distortion and selectivity prevention: because the analysis after the change in theoretical framework occurred a significant amount of time after the observations, limited reliance is made in this study of researcher recalls of events. Instead, the primary source of data in this study are the audio recordings, field notes, and initial research publications made within a year of completion of the study.

(iii) triangulation: as above, assertions were checked across multiple data sources, which include: field notes, audio recordings, and student work.

(iv) debriefing: early versions of the research report were presented at international conferences to gather feedback from neutral referees.

(v)  member checks: drafts of research reports were shown to participants for their authentication and for the opportunity for them to offer additional information.

(vi) transferability through thick description: a well developed description of each of the case study contexts is offered as a means to aid transferability of the study.

(vii) research journal: A research journal was maintained to record reflexive thought, schedules and logistics, and methodological decisions made through the study.

## 11.    Chapter summary

In this chapter, I have laid out the framework for the collection, analysis and reporting of research designed to provide meaningful responses to the research questions, which I have also identified in relation to the socio-political context that educational institutions are embedded in. To reiterate a general form of the research questions within the language of the theoretical framework of this project, the aim here is to study the effects of well-intentioned policy revisions on curriculum and pedagogy, given the theoretical assertion derived from principles of social realism that knowledges are not infintely pliable. An *a priori* coding scheme for curriculum and pedagoguical analysis has been detailed, operationalizing the Legitimation Code Theory concepts of semantic gravity (context dependency) and density (symbolic condensation), and the semantic range.

# Chapter 5
# Curriculum analysis

Before a detailed analysis of the curriculum document is carried out, it would be useful to signpost the organization of the curriculum document and the metaphorical path through the forest of data here. To begin, there are two versions of the curriculum document, for the elementary grades, an older version dating from 1998, and a newer one from 2007. In both, the rough organization of the documents are similar, with some front matter discussing the aims of the program of science and technology, achievement levels, and general implementation guidelines. At the end of the document is a glossary of terms. In the middle are the learning objectives for the program, which are divided into grade year pacing, and thematically organized into knowledge categories called strands (akin to organization along the physics/chemistry/biology in the upper grades) which are unchanged throughout the grade years. For any specific year, any indiviudal strand is called a unit, and these units are further subdivided into three sections. Typical pages from the older and the revised versions of the elementary curriculum are shown in the next two pages (see Fig. 5.1 and 5.2), with the unit of analysis highlighted.

These three sections are called, for the older curriculum: "Understanding Basic Concepts", "Developing Skills of Inquiry, Design, and Communication", and "Relating Science and Technology to the World Outside the School". In the revised curriculum, these categories are labelled "Relating Science and Technology to Society and the Environment", "Developing Investigation and Communication Skills", and "Understanding Basic Concepts". The individual statements that form the specific objectives of the units of study form the unit of analysis in the coding scheme de-

veloped for this study. As a means for presenting this analysis, I will begin by describing gross differences, and progress via successive increases in detail.

## Life Systems: Grade 8 – Cells, Tissues, Organs, and Systems

### Overview

In Grade 5, students were introduced to the cell as the basic unit of life in the study of human organ systems. In Grade 8, students will continue to develop their knowledge of systems in living things, focusing on the structure and function of cells in plants and animals and on the organization of cells into tissues, organs, and organ systems.

### Overall Expectations

By the end of Grade 8, students will:

• demonstrate an understanding of the basic structure and function of plant and animal cells, and describe the hierarchical organization of cells in plants and animals;

• investigate basic cellular processes and certain specialized cells in plants;

• describe ways in which study of the structure, function, and interdependence of human organ systems can result in improvements in human health.

### Specific Expectations

*unit of analysis*

**Understanding Basic Concepts**
By the end of Grade 8, students will:

– identify unicellular organisms (e.g., amoebae) and multicellular organisms (e.g., worms, humans);

– investigate ways in which unicellular organisms meet their basic needs (e.g., for food, movement);

– identify organelles in cells through observation (e.g., vacuole, nucleus, chloroplast) and explain their functions;

– describe, using their observations, differences in structure between plant and animal cells;

– describe the organization of cells into tissues, organs, and systems;

– explain the function of selectively permeable membranes in cells;

– describe and explain the structure and function of specialized cells and tissues in different parts of plants (e.g., in roots, stems, leaves);

– recognize that cells in multicellular organisms need to reproduce to make more cells to form and repair tissues;

– explain how the structure of the roots, stem, and leaves of a plant permit the movement of food, water, and gases;

– compare the structure of different plants (e.g., cactus, coniferous tree, moss) and show how their structure enables them to live in specific conditions;

– describe, using their observations, the movement of gases and water into and out of cells during diffusion and osmosis.

**Developing Skills of Inquiry, Design, and Communication**
By the end of Grade 8, students will:

– use a microscope accurately to find, observe, and draw microscopic objects;

– formulate questions about and identify needs related to the functioning of cells, and explore possible answers to these questions and ways of meeting these needs (e.g., design and conduct an experiment to test a hypothesis about the effect of chemicals on a unicellular organism; design and conduct an experiment to test the effectiveness of different substances in preventing cut flowers from wilting);

Figure 5.1: Extract from older elementary curriculum document, unit of analysis is highlighted

## SPECIFIC EXPECTATIONS

### 1. Relating Science and Technology to Society and the Environment

By the end of Grade 7, students will:

**1.1** assess the social and environmental benefits of technologies that reduce heat loss or transfer *(e.g., insulated clothing, building insulation, green roofs, energy-efficient buildings)*

*Sample guiding questions:* (a) Insulated clothing protects our bodies and increases our ability to enjoy outdoor activities in winter. What science and technology concepts are at work in coats designed for use in cold weather? Who might be interested in such designs? (b) A well-insulated home is more comfortable and costs less to heat. Reducing heat loss saves energy, and saving energy reduces the environmental impact of energy production. What are some areas of your home where heat might be lost? How can this heat loss be counteracted? What are the benefits of doing so? (c) Green roofs save on heating and cooling costs and reduce the amount of insulation that is needed. But they have not gained wide acceptance in Ontario. What might be some deterrents to having a green roof? How might these deterrents be overcome? (d) Energy-efficient buildings are extremely airtight compared to conventionally constructed buildings. This minimizes the amount of warm (or cool) air that can pass through the structure. What are some of the disadvantages to having airtight buildings *(e.g., lack of fresh air, moisture buildup)*? How can these problems be solved *(e.g., through mechanical ventilation systems with heat recovery and humidity control)*, and how effective are the solutions?

**1.2** assess the environmental and economic impacts of using conventional *(e.g., fossil fuel, nuclear)* and alternative forms of energy *(e.g., geothermal, solar, wind, wave, biofuel)*

*Sample issues:* (a) Your family is building a new home. Present a case for installing a geothermal heat pump. In your discussion, be sure to include the benefits and costs from both an environmental perspective and an economic perspective. (b) Make a case for (or against) using rural land or marginal land-use areas for wind turbine farms.

### 2. Developing Investigation and Communication Skills

By the end of Grade 7, students will:

**2.1** follow established safety procedures for using heating appliances and handling hot materials *(e.g., use protective gloves when removing items from hot plates)*

**2.2** investigate the effects of heating and cooling on the volume of a solid, a liquid, and a gas

**2.3** use technological problem-solving skills (see page 16) to identify ways to minimize heat loss

*Sample problem:* Use the materials provided to create a product (e.g., a model of a piece of winter clothing, a model of a wet suit, a model travel mug for a hot beverage or food item) that will minimize heat loss

**2.4** use scientific inquiry/experimentation skills (see page 12) to investigate heat transfer through conduction, convection, and radiation

*Sample problem (conduction):* After letting spoons made of different materials sit partially submerged in a container of hot water, measure the temperature of the parts sticking out of the water. What conclusions can you draw from your findings?

**2.5** use appropriate science and technology vocabulary, including *heat*, *temperature*, *conduction*, *convection*, and *radiation*, in oral and written communication

**2.6** use a variety of forms *(e.g., oral, written, graphic, multimedia)* to communicate with different audiences and for a variety of purposes *(e.g., using the conventions of science, create a labelled diagram to illustrate convection in a liquid or a gas)*

### 3. Understanding Basic Concepts

By the end of Grade 7, students will:

**3.1** use the particle theory to compare how heat affects the motion of particles in a solid, a liquid, and a gas

**3.2** identify ways in which heat is produced *(e.g., burning fossil and renewable fuels, electrical resistance, physical activity)*

*unit of analysis*

Figure 5.2: Extract from revised elementary curriculum document, unit of analysis is highlighted

## 1. Macroscopic changes

Perhaps the most striking difference between the older and revised documents is an almost 52% increase in page length of the revised document, from 110 pages to 167. A look at the table of contents reveals that a lot of the page budget of the revised document has been taken up by additional frontmatter—42 pages as opposed to the 13 pages of older curriculum document. A significant contributor to this page count derives from the directions to teachers as to how the science and technology program interacts with other schooling considerations such as 'cross-curricular and integrated learning', 'program considerations for English language learners', 'environmental education', 'critical thinking and critical literacy in science and technology', and 'antidiscriminatory education in the science and technology program'. Also contributory to the increase in page length is the inclusion of elements of the influential teacher lesson design framework Understanding by Design by Wiggins and McTighe (2005). While the frontmatter writeup for this framework takes all of one page, the formatting for the lesson units in the revised document include a 'fundamental ideas' and 'big ideas' section, which contribute to the page length. It is interesting to note here that within the page length dedicated to explaining the nature of 'Big Ideas', the following possibly cryptic diagram is presented with little elaboration as to the nature of relations between the individual terms:
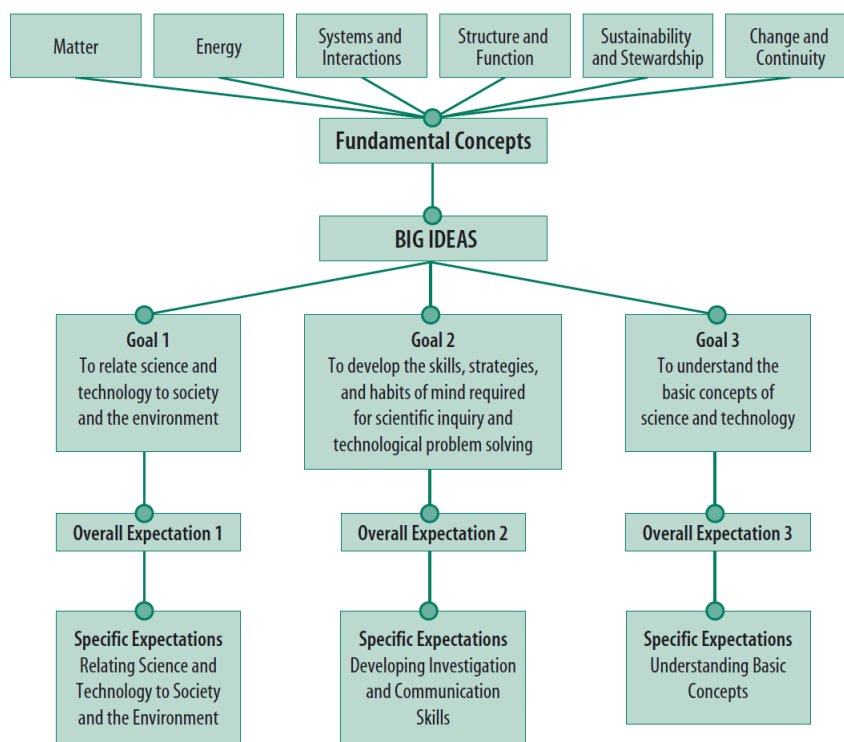
Figure 5.3: 'Big Ideas' figure from revised elementary curriculum

It is therefore rather puzzling to note the other more substantive changes to the content of the science and technology program. For example, in the older curriculum, each unit had on average 21.5 specific expectations within a range of 14 to 30; but in the revised curriculum, that number has changed to 14.9 within a range of 11 to 18. In addition, the revised expectations have not been re-written to with greater verbosity. What is also of interest is the manner in which content reduction has taken place. The older curriculum has five strands compared to the revised:

| Older curriculum | Revised curriculum |
| --- | --- |
| Life Systems | Understanding Life Systems |
| Matter and Materials | Understanding Structures and Mechanisms |
| Energy and Control | Understanding Matter and Energy |
| Structures and Mechanisms | Understanding Earth and Space Systems |
| Earth and Space Systems | |

Table 5.1: Strands in the older and revised curricula

The manner in which this reduction has occurred will be discussed in detail in a later section. Continuing on the theme of macroscopic changes to the documents, the order of presentation of the lesson units have also changed. In the older document, lesson units were organized sequentially by strand, listing the progression of ideas throughout the grade levels. In the revised document, units are organized by grade level:
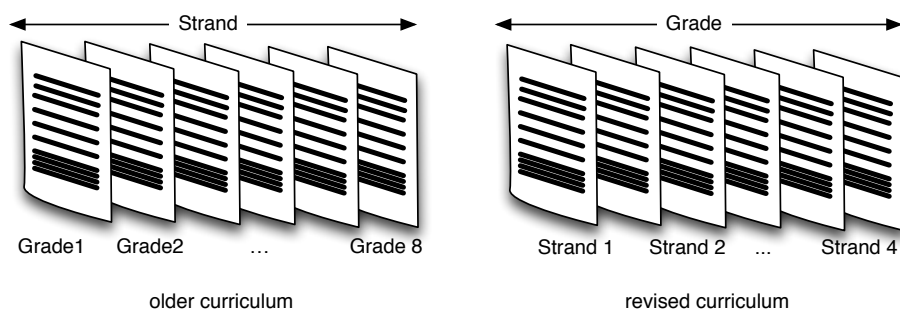


Figure 5.4: Curriculum organization by strand and grade

In addition to these structural changes, individual lesson unit organization has been modified. The orders of presentation for the older and revised curricula are presented below:

| older curriculum | Understanding Basic Concepts →Developing Skills of Inquiry→Relating Science and Technology to the World Outside the School |
|---|---|
| revised curriculum | Relating Science and Technology to Society and the Environment→Developing Investigation and Communication Skills→Understanding Basic Concepts |

Table 5.2: Order of specific expectations, older and revised curricula

Also of note are the number of specific expectations for the Science, Technology, World (STW) and the revised Science Technology, Society, Environment (STSE): the older STW section had an average of 7.68 expectations (ranging from 3 to 14), while the revised STSE section had an average of 1.97 expectations (from 1 to 3).

### 5.1.1    Discussion

Even from the outset, there are clear indications that this revision is not meant to be an evolutionary development over its predecessor. Content organization by grade rather than by strand could be justified on the grounds that as a guiding document for teachers preparing lessons for their students in any particular year, it might be useful for teachers not to have to skip pages to access content spread out throughout the document. However, from a social semiotic standpoint (see, e.g., Kress & Van Leeuwen, 2006), one could argue that this style of presentation deprivileges the cumulative knowledge building modality, and de-emphasizes the diachronic linkages and connections *within* a knowledge strand, instead emphasizing the synchronic connections between knowledge *between* strands in any given year. Admittedly this is an extremely weak argument as teachers are free to turn the pages in their preferred order, but nonetheless, the mode of presentation may offer a hint as to the underlying models of the structuring of knowledge of the curriculum planners. If nothing at all, perhaps in the older curriculum we see a stronger statement

of the importance of diachronic development of knowledge especially since organization by strand actually inconveniences users of the document.

Another means of signalling the radical break with the older curriculum may be found in the change in presentation order of the specific expectations, from STW as the last section to STSE as the first section in the revised document. In speaking with several interviewees for a different project (Tan & Pedretti, 2010), this change was remarked upon as significant, and signalling to teachers the importance and primacy of the STSE expectations, as something that should be done prior to teaching the basic concepts. Worth reiterating at this moment are the content reduction moves: (i) reduction in number of strands, and (ii) reduction in number of specific expectations overall for each unit ($21.5 \rightarrow 14.9$), and specifically for the STW/STSE expectations ($7.68 \rightarrow 1.97$). A detailed description of the content reduction will be discussed in the next section.

## 2.      Curriculum content reduction

As mentioned, perhaps one of the most significant structural change to be made to the science curriculum is to be found the content reduction, from five strands of the older curriculum to four in the revised one. Here, the scope and magnitude of these changes will be described. From the outset, the strand titles indicate the degree of elision made to the older curriculum, 'Materials' and 'Control' appear to have been removed. However, some of the concepts have been retained under another strand or moved to a later grade for introduction. The changes are summarized in tabular form below:

| Units removed from older curriculum... | ...reappearing in revised curriculum in/as | Notes |
|---|---|---|
| "Characteristics of objects and properties of materials" (Grade 1) | combined with unit "Everyday structures" to become "Materials, objects, and everyday structures" (Grade 1) | Two units in older curriculum with relatively high redundancy combined with minimal loss of significant content knowledge. |
| "Energy from wind and moving water" (Grade 2) | (closest match) "Air and water in the environment" (Grade 2) | Significant specific expectations not found in revised curriculum:<br>•identify movement as an outcome of energy input<br>•ask questions about and identify needs and problems related to the use of wind and moving water as energy sources, and explore possible answers and solutions |
| "Magnetic and charged materials" (Grade 3) | (closest match) "Forces causing movement" (Grade 3). Some expectations are also found in the Grade 6 unit "Electricity and electrical devices". | Significant specific expectations not found in revised curriculum:<br>•classify, using their observations, materials that are magnetic and not magnetic, and identify materials that can be magnetized.<br>•identify, through observation, the effect of different conditions on the strength of magnets and on static electric charges in materials.<br>•compare different materials by measuring their magnetic strength or the strength of their electric charge.<br>•determine, through observation, the polarity of a magnet.<br>•identify materials that can be placed between a magnet and an attracted object without diminishing the strength of the attraction.<br>•predict, verify, and describe the interaction of two objects that are similarly charged.<br>•describe, through observation, changes in the force of attraction at different distances, both for magnetic forces and for static electric forces. |
| "Materials that transmit, reflect of absorb light or sound" (Grade 4) | "Light and Sound" (Grade 4) | Significant specific expectations not found in revised curriculum:<br>•classify materials as transparent, translucent, or opaque.<br>•demonstrate how opaque materials absorb light and thereby cast shadows. |

| "Conservation of energy" (Grade 5) | "Conservation of energy and resources" (Grade 5) | Change is essentially a renaming |
|---|---|---|
| "Motion" (Grade 6) | no clearly defined replacement | Significant specific expectations not found in revised curriculum:<br><br>•demonstrate awareness that a moving mass has kinetic energy that can be transferred to a stationary object. |
| "Heat" (Grade 7) | "Heat in the environment" (Grade 7) | Significant specific expectations not found in revised curriculum:<br><br>•distinguish between the concept of temperature and the concept of heat (e.g., temperature is a measure of the average kinetic energy of the molecules in a substance; heat is thermal energy that is transferred from one substance to another).<br><br>•investigate and identify factors affecting the rate of temperature change.<br><br>•describe the effect of heat on the motion of particles and explain how changes of state occur. |
| "The Earth's crust" (Grade 7) | (closest match) "Rocks and Minerals" (Grade 4) | Significant specific expectations not found in revised curriculum:<br><br>•describe the composition of the earth's crust<br><br>•describe, using simulations or models, the processes involved in mountain formation and in the folding and faulting of the earth's surface (e.g., plate tectonics).<br><br>•analyze, through observation, evidence of geological change (e.g., fossils, strata).<br><br>•describe, using simulations or models, the origin and history of natural features of the local landscape.<br><br>•explain the causes of some natural events that occur on or near the earth's surface (e.g., earthquakes, volcanic eruptions, landslides) and their effects. |
| "Cells, tissues, organs, and systems" (Grade 8) | "Cells" (Grade 8) | Significant specific expectations not found in revised curriculum:<br><br>•explain the function of selectively permeable membranes in cells.<br><br>•describe some ways in which the various systems in the human body are interdependent.<br><br>•describe similarities and differences in the functions of comparable structures in different groups of living things. |

| "Optics" (Grade 8) | "Light and geometric optics" (Grade **10** Physics) | Superset of topics are covered in grade 10. |
|---|---|---|
| "Mechanical efficiency" (Grade 8) | "Fluids" (Grade 8) | Significant specific expectations not found in revised curriculum: •investigate and measure forces that affect the movement of an object (e.g., friction). •distinguish between velocity and speed (i.e., define velocity as speed in a given direction). •determine the velocity ratio of devices with pulleys and gears (i.e., divide the •distance that a load moves by the distance covered by the force (effort) required to move it) •predict the mechanical efficiency of using different mechanical systems (e.g., a winch). |

Table 5.3: List of elided specific expectations in the revised elementary curriculum

*5.2.1        Observations*

Without delving into the contributory causes for curriculum reduction, there appears to be a trend with the content that has been left out of the revised curriculum. A large number of removed expectations (not listed in the table above) belong to the category of knowledge propositions which are low in the semantic range; for example, in the grade 7 unit on 'heat', are these two elided expectations:

• identify systems that are controlled by sensory inputs and feedbacks (e.g., a thermostat);

• design and build a device that minimizes energy transfer (e.g., an incubator, a Thermos flask).

or, for a grade 4 unit on "Light and sound energy":

• identify different uses of light at home, at school, or in the community, and explain how their brightness and colour are related to their purpose

- describe, using their observations, how sounds are produced in a variety of musical instruments (e.g., wind instruments) and identify those they like listening to best

These expectations in general either do the epistemological task of pointing out what instances of phenomena mean, or are practical activities that make use of general principles, but are not especially useful in helping students learn the principles themselves. For example, designing and building an incubator or thermos flask may take a large amount of class time, but the knowledge gains may be minimal, and involve primarily manual skills. While this is not to denigrate manual skills which remain useful for students to acquire, there is a sense here that these tasks may be better suited in a design and technology curriculum, where there is a specific emphasis on designing machines and working with materials to build something. This is especially since the expectation does not outline what scientific principle is to be acquired through the process; it would have definitely been an improvement to have modified the expectation to read "design and build a device that minimizes energy transfer, and compare different designs, noting features which improve thermal insulation". Removal of these kinds of expectations are welcome developments within the interpretive framework of this study.

However, the same cannot be said about the specific expectations listed in Table 5.3 above. These specific expectations listed here are either help to develop general principles via an inductive epistemological move of collecting instances of phenomena and referring to the principle underlying the phenomena, or are statements of the general principle themselves. The elision of these expectations are a cause for concern, especially from the perspective of this research study. Drawing from Young's conception of powerful knowledges, and Bernstein's classification of hierarchical knowledge structures, the point here is to indicate that these elided expectations may be categor-

ized as powerful knowledges or overarching axioms of high explanatory utility, capable of subsuming many empirical phenomena. To be sure, this point is probably under-developed here as there has not been a considered attempt at operationalizing the empirical referent of the theoretical concept of 'powerful knowledge' (as opposed to something which is not, for example). Also, there is no sense here of a comparison between these expectations which have been elided and those that remain in the revised curriculum—there is always the possibility that, for example, far more powerful knowledges have been retained or developed which subsumes these elided expectations. On top of these caveats, there exists the lack of a normative optimum curriculum to which these elisions may be said to indicate a shortcoming. With these qualifiers in place, perhaps the conclusion to be drawn here is that there are reasons to support a more detailed analysis of the curriculum to study the changes due to the revision. Such an analysis follows.

## 3.      Quantitative analysis

Recall that a theoretical concern for the semantic gravity and density was the description of a series of changes to the semantic range of knowledge (re)production in order to show the oscillating nature of semantic gravity and density with time. Because of the privileging of the cumulative knowledge building modality here, the absolute values of the semantic gravity and density at any one time is less important than its relation in a series of knowledge (re)production. Knowledge propositions of higher or lower semantic gravity and density can be equally valued; each type plays a role in the cumulative modality of successively increasing and decreasing the semantic range of a lesson, unit, or strand. Therefore, there is no direct tabulation of code frequencies. In addition, the eventual outcome of cumulative knowledge building sequence should be knowledge forms high on the semantic range—subsuming the greatest amount of empirical phenomena (including

contexts unforeseen), with the maximum of conceptual parsimony. In considering the typical content analysis methods available, there appears to be a lack of ability to capture this form of variability with time; most statistical measures are concerned with either establishing the goodness of fit (or otherwise) with a known distribution, or measuring the degree of difference of a measure of central tendency with another quantity. Because of the inherent mathematical difficulty of describing this oscillatory relation, a simplified approach is taken instead, detailed as follows.

From the coding scheme, we arrive at a two term code for each specific expectation. These codes are transformed into a Likert scale by (arbitrarily) assigning the value of '+' to '2', and '–' to '1', and taking into account that a typical unit has 15 to 20 expectations, hence, some interval-level quantitative operations are permissible (Punch, 2009; Wiersma, 2000). Because there is a theoretical commitment here to examining the development of knowledge through time, these individual codes are averaged for each unit, and these averages for a strand are charted with the grade level on the horizontal axis. For example, the older curriculum Life Systems strand is shown below:
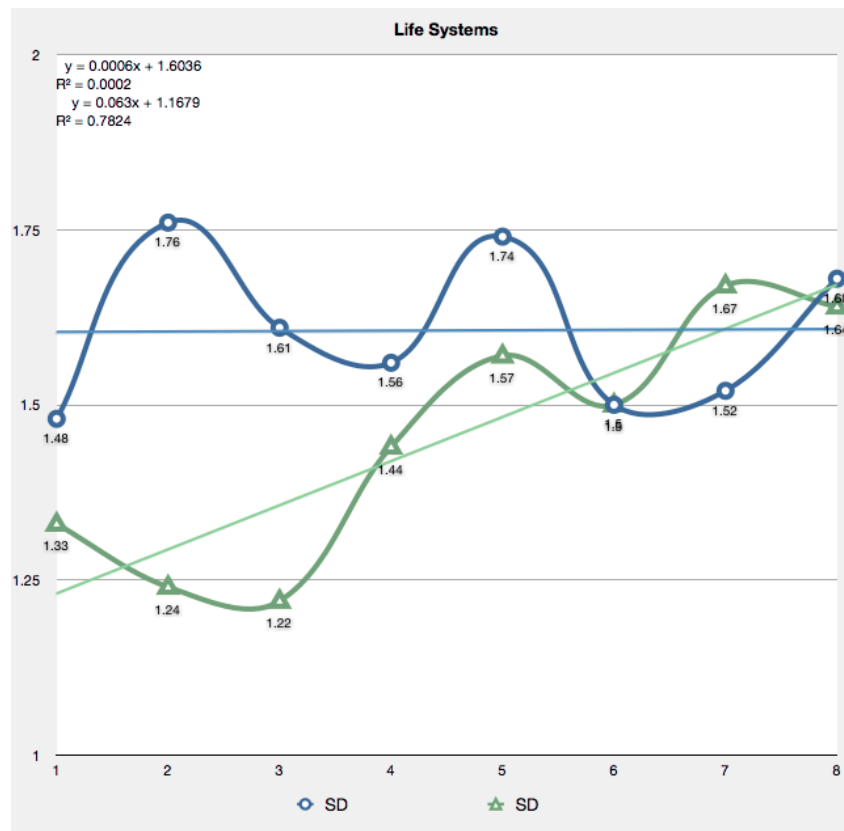
Figure 5.5: Older curriculum Life Systems strand—chart of semantic gravity/density against grade level

Note once again that semantic gravity (SG) indicates the degree of contextualization of a concept, stronger gravity (value 2) indicating a higher degree of context dependency, while semantic density (SD) refers to the meaning condensation, stronger density (value 2) indicates a higher degree of condensation and abstraction. Arbitrarily, linear regression lines have been added to the chart, as there is no theoretical preference as to the choice of regression model.

There are a few features of such a graph which will be useful for subsequent discussion:

i) A line has been drawn to connect the data points for semantic gravity, and semantic density as it varies across the grades. This procedure is borderline mathematically dubious as the line illus-

trates some form of relationship where there may not exist one in reality, or may not exist in the form illustrated by the chart. On the other hand, as these units are meant to be integrated as a plan of study over the grades, there is a theoretical precedent to claim a connection and cumulative building up of content in the later grades based on the material learnt in the lower grades. It is in order to illustrate the degree of relation that the points have been connected by lines.

ii) the slope of the regression line illustrates the general trend for the strand across the eight grades of elementary school. We may tend compare between increasing, decreasing, or level slopes. In this case, the semantic gravity slope is fairly flat (=0.0006), indicating that the context dependency of the strand did not make a net 'movement' over the eight years, even though there was year-to-year variation. On the other hand, semantic density increased through the years, meaning that the terms used by students in the upper grades condensed more meaning than those used by the students in the lower grades.

## 4.      Older Curriculum

In this section, the older curriculum will be characterized using the measures developed through this study. Here, the concern is not yet to make substantive comparisons between curriculum documents, but to identify particular attributes and explore the descriptive capacity of the measurements used. Because the quantitative measures condense a large amount of data, this section is presented as a form of a baseline, from which the changes in the revised curriculum may be better appreciated in relief.

*5.4.1        Semantic gravity trend–older curriculum*

Across the five strands of the older curriculum, semantic gravity generally weakens with grade level; the specific expectations become progressively less context dependent as grade level increases. Comparing the regression line gradients:

| Strand | Life Systems | Matter and Materials | Energy and Control | Structures and Mechanisms | Earth and Space Systems |
|---|---|---|---|---|---|
| Semantic gravity gradient | 0.0006 | –0.0092 | –0.0252 | –0.0399 | –0.0330 |

Table 5.4: Semantic gravity regression line gradient for older elementary strands

The regression line gradients are generally weakly negative, except for the Life Systems strand. In other words, for each strand, the content knowledge becomes increasingly context independent. This is a generally expected development; for example, consider the units for the Structures and Mechanisms strand, which has the steepest negative gradient:

| Grade | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Unit | Everyday Structures | Movement | Stability | Pulleys and gears | Forces acting on structures and mechanisms | Motion | Structural strength and stability | Mechanical Efficiency |

Table 5.5: Unit titles for Structures and Mechanisms strand, older elementary science curriculum

There is a strong sense of 'building upon' of concepts, from the early grade 'pointing out' empirical phenomena and introduction to scientifically interesting problem situations before later grade topics introduce sophisticated terminology and theories to subsume the earlier topics into its explanatory framework. It is also not surprising to note that the gradient of the semantic density regression line, at 0.0395, is also the steepest. In some ways, this result is not unexpected; when

Bernstein (2000, p. 163) developed his differentiation of knowledge types between the hierarchical and the horizontal, the model for hierarchical knowledge has been a natural science, specifically physics. *Structures and Mechanisms* deals with concepts which most resemble physics. In contrast, for Life Systems, the units for this strand are:

| Grade | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Unit | Characteristics and needs of living things | Growth and changes in animals | Growth and changes in plants | Habitats and communities | Human organ systems | Diversity of living things | Interactions within ecosystems | Cells, tissues, organs and systems |

Table 5.6: Unit titles for Life Systems strand, older elementary science curriculum

For the Life Systems strand, there is a comparatively weaker sense of hierarchical organization between the units in this series; for example, *Habitats and Communities* in grade 4 does not appear to be a significant empirical base from which concepts in grade 5 *Human Organ Systems* are built upon. Again, this is not necessarily a negative observation, but rather a demonstration of the differences in knowledge forms in use in elementary science. For another example—the mathematical topics of calculus and trigonometry (say) could be taught independently of knowledge of the other; there is no intention here to privilege hierarchical knowledge structures over the horizontal.

### 5.4.2    *Semantic gravity trend for STW expectations—older curriculum*

In the older curriculum document, curriculum expectations that most fit the task of environmental education were located within units in the STW section. In contrast to the explicit environmental bias of the revised curriculum, the STW section appears to have a 'looser' emphasis on more general applications of science to everyday contexts which are familiar to learners. In effect, these STW expectations become meaningful extensions of curriculum content, demonstrating scientific concepts in action, or pointing out phenomena from which scientific concepts may be de-

veloped. It is not unsurprising that the semantic gravity trend for STW expectations alone re-
semble that for all expectations counted together:

| Strand | Life Systems | Matter and Materials | Energy and Control | Structures and Mechanisms | Earth and Space Systems |
|---|---|---|---|---|---|
| Semantic gravity gradient | –0.0188 | –0.0006 | –0.0263 | –0.0242 | –0.0550 |

Table 5.7: Semantic gravity regression line gradients for STW expectations, older curriculum

The trend for all the strands in the elementary curriculum is for a decrease in semantic gravity as
the grade level progresses; there is a decrease in context dependency of the specific expectations of
the STW section.

### 5.4.3 *Semantic density trend–older curriculum*

As for the semantic density regression lines, the gradients are found as follows:

| Strand | Life Systems | Matter and Materials | Energy and Control | Structures and Mechanisms | Earth and Space Systems |
|---|---|---|---|---|---|
| Semantic Density gradient | 0.0630 | 0.0229 | –0.0112 | 0.0395 | 0.0236 |

Table 5.8: Semantic density regression line gradient for elementary strands

For semantic density, there is a general trend among the knowledge strands for density to increase
with grade level–symbols (text and scientific concepts) at the higher grades condense more mean-
ing; and with increasing student ability in the higher grades, an increase in abstraction, technicaliz-
ation and complexity of ideas delivered in the classroom. Unusually for the *Energy and Control*
strand however, there appears to be a decrease in semantic density at the upper grades. A look at
the units may reveal an explanation:

| Grade | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-------|---|---|---|---|---|---|---|---|
| Unit | Energy in our lives | Energy from wind and moving water | Forces and movement | Light and sound energy | Conserva-tion of energy | Electricity | Heat | Optics |

Table 5.9: Unit titles for Energy and Control strand, older elementary science curriculum

While the context dependency and degree of abstraction of the units in this strand appear to decrease with grade (see gravity gradient), the individual units serve as introductions to the various forms of energy, and hence the semantic density of terms does not increase with grade level. For example, in introductory electricity, the emphasis is with a qualitative treatment, no sophisticated, meaning dense concepts like current or potential difference are discussed.

### 5.4.4    *Semantic density trend–STW expectations*

As with the semantic gravity, the semantic density for STW expectations followed closely the general trend for all expectations combined:

| Strand | Life Systems | Matter and Materials | Energy and Control | Structures and Mechanisms | Earth and Space Systems |
|--------|-------------|----------------------|--------------------|---------------------------|-------------------------|
| Semantic density gradient | 0.0862 | 0.0565 | 0.0382 | 0.0296 | 0.0550 |

Table 5.10: Semantic gravity regression line gradients for STW expectations, older curriculum

Semantic density increases with grade level for STW expectations, indicating that concepts and symbols used in the STW section condense more meaning in the upper grades for the older curriculum. Again, this trend is similar to that for the behaviour of all expectations combined.

*5.4.5        Summary for older curriculum*

While there is no attempt to depict the older curriculum in any normative light to highlight the deviations in the revisions, there nonetheless are reasons to support the proposition that the older curriculum appears to be a fairly well developed curriculum document. The general trend for strands of knowledge in the older curriculum is for a cumulative 'building up' of knowledge, with weakening semantic gravity and strengthening semantic density as the strand develops through the eight grades of elementary school. While outliers exist, the behaviour is easily explained by reference to the specific objectives or strand structure. Importantly, the STW section of the older curriculum appears to be a cohesive extension of the science curriculum, displaying similar behaviour for semantic gravity and density as the specific expectations for all sections combined.

## 5.        Revised curriculum

With a curriculum reduction collapsing two of the older strands into a newer combination, only three of the revised curriculum strands may be directly compared with the older curriculum. As previously noted, one of the most significant changes has been in the reduction of number of specific expectations, generally, and in the now-renamed STSE section. With essentially only two expectations for this section, comparisons between the STSE section and the rest of the unit are not too meaningful. In similar sequence to the above section, the results are presented below[22].

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22.  please note that since the graphs of semantic gravity and density change over grades are not being directly compared here, these graphs have been omitted.

*5.5.1        Semantic gravity trend*

The semantic gravity trend for the revised curriculum demonstrates a rather flat trend across the grade levels:

| Revised strand | Understanding Life Systems | Understanding Structures and Mechanisms | Understanding Matter and Energy | | Understanding Earth and Space Systems |
|---|---|---|---|---|---|
| semantic gravity gradient | –0.0070 | 0.0004 | 0.0019 | | 0.0300 |
| Older strand | Life Systems | Structures and Mechanisms | Matter and Materials | Energy and Control | Earth and Space Systems |
| semantic gravity gradient | 0.0006 | –0.0399 | –0.092 | –0.0252 | –0.0330 |

Table 5.11: Comparing semantic gravity regression line gradients

For the three strands directly comparable, notice that for all of them, the semantic gravity trend has been reversed in order, most importantly for the units of *Structures and Mechanisms*, and *Earth and Space Systems*, for which the semantic gravity trend has changed from decreasing in the older curriculum to increasing in the revised one. In other words, while context dependency in the older curriculum generally decreased with grade level, the revised curriculum has units which become more context dependent as grade level increases. Even comparing the merged strand (*Matter and Energy*) with its predecessors (*Matter and Materials* and *Energy and Control*), the older strands have a generally decreasing semantic gravity trend, while the revised strand has an increasing trend.

To some extent, the merger of two strands to form a revised strand may contribute to its change in semantic gravity trend—in order to accommodate the compression of a large amount of knowledge objectives, only the higher semantic gravity, more context dependent units and expectations may have been retained. However, the change in other equivalent strands requires more ex-

planation. Through coding the curriculum document, the general impression that arises is that there has been a movement toward curriculum reduction and simplification, removing 'difficult' ideas and concepts which have less application in familiar contexts in favour of retaining expectations which appear to have a greater immediate contextual application and familiarity among students. A fuller discussion of this phenomenon will follow.

*5.5.2        Semantic density trend*

To reiterate, there is a theoretical preference for semantic density to be increasing with time, for symbols, language, and concepts to condense greater meaning as students progress through grade levels. Ideally, this should be demonstrated in use of more sophisticated scientific terminology and symbols as students are inducted into the scientific world-view. In addition, for elementary grade students, as they mature, there should also be a concomitant increase in their abilities to work with meaning dense symbols and relations, and the curriculum should recognize such development. The semantic density trend for the revised curriculum is tabulated below:

| Revised strand | Understanding Life Systems | Understanding Structures and Mechanisms | Understanding Matter and Energy | | Understanding Earth and Space Systems |
|---|---|---|---|---|---|
| semantic density gradient | 0.0070 | –0.0114 | –0.0066 | | –0.0343 |
| Older strand | Life Systems | Structures and Mechanisms | Matter and Materials | Energy and Control | Earth and Space Systems |
| semantic density gradient | 0.0630 | 0.0229 | –0.0112 | 0.0395 | 0.0236 |

Table 5.12: Comparing semantic density regression line gradients

The semantic density trend for the revised curriculum displays a marked difference from the older curriculum in that there are now three out of four strands that have a decreasing semantic density

trend; in other words, concepts condense progressively less meaning at higher grades. As with the observation for semantic gravity, this may largely be attributable to the content reduction. Also contributory to this state of affairs is the nature of the STSE expectations, which tend to coded as low semantic density. A fuller discussion follows.

*5.5.3        STSE expectations*

In contrast to the older curriculum, the revised curriculum has a greatly reduced number of expectations (to only 2 per unit) for this section. As such, reporting variations of quantitative measures across a strand is not meaningful as small changes in scores create large effects on the regression statistics. Instead, the average rating for strands (averaging for all grade levels in each strand) are tabled below:

| Strand | Understanding Life Systems | Understanding Structures and Mechanisms | Understanding Matter and Energy | Understanding Earth and Space Systems |
|---|---|---|---|---|
| Semantic gravity average | 1.88 | 1.88 | 1.88 | 1.52 |
| Semantic density average | 1.13 | 1.13 | 1.13 | 1.48 |

Table 5.13: Semantic gravity and density average for STSE expectations, revised curriculum

The principal feature of the STSE expectations are its location on the semantic range—the vast majority of the specific expectations are of higher semantic gravity, and weaker semantic density, in other words, the STSE expectations tend to be knowledge propositions describing discrete phenomena with language that does not condense large amounts of meaning. Taken individually, such knowledge propositions have its place—it is useful to have good description of what amounts to phenomena of interest to building theory. However, because there is little change in the gravity and density of the STSE expectations (within a unit, grade, or strand), the STSE expectations form

a veritable low flatline—the ideas introduced in this section are not subsumed into higher order explicatory structures that have lower context dependency and higher symbolic condensation. In other words, the STSE expectations do not 'go anywhere' toward building a hierarchical structure of knowledge; instead, these expectations appear to develop knowledge segmentally, where STSE knowledge learnt in the earlier grades or in different units do not inform the acquisition of later expectations.

## 6.      Effect on semantic range comparison—all expectations

In addition to coding the specific expectations for semantic gravity and density, specific expectations could also be said to influence the semantic range—a specific expectation could do one of the following: (i) work with theory without empirical demonstration (high flatline); (ii) generalize empirical phenomena toward the development of theoretical concepts (increasing the semantic range); (iii) explicate theoretical concepts by deliberate demonstration with empirical phenomena (decreasing the semantic range); or (iv) work with empirical phenomena without attempting to develop generalized theoretical concepts, or explicitly connecting knowledge under subsuming framework (low flatline). The specific expectations were coded for effect on semantic range (ESR), and the comparative results for the two curricula are shown in charts below. In these charts, data is displayed by strand for each chart. Codes for all expectations in all units across the eight grades have been counted, and the fraction belonging to each code category is displayed, blue (upper) bars for the revised curriculum, and green (lower) bars for the older curriculum. For the merged strands, the revised strand has been compared to the two older strands counted together.
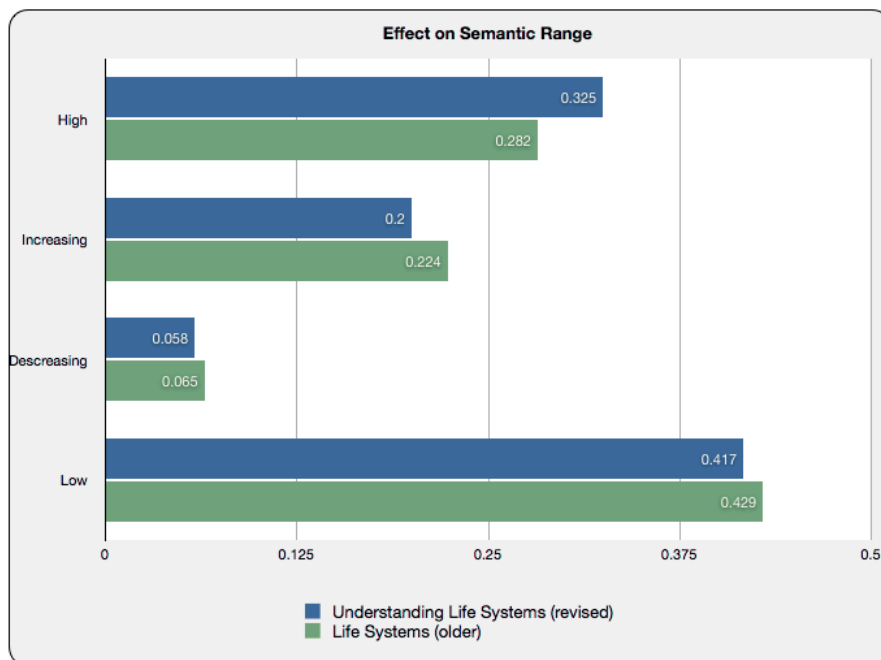
Figure 5.6: ESR comparison—Understanding Life Systems (upper bar) versus Life Systems (lower bar)
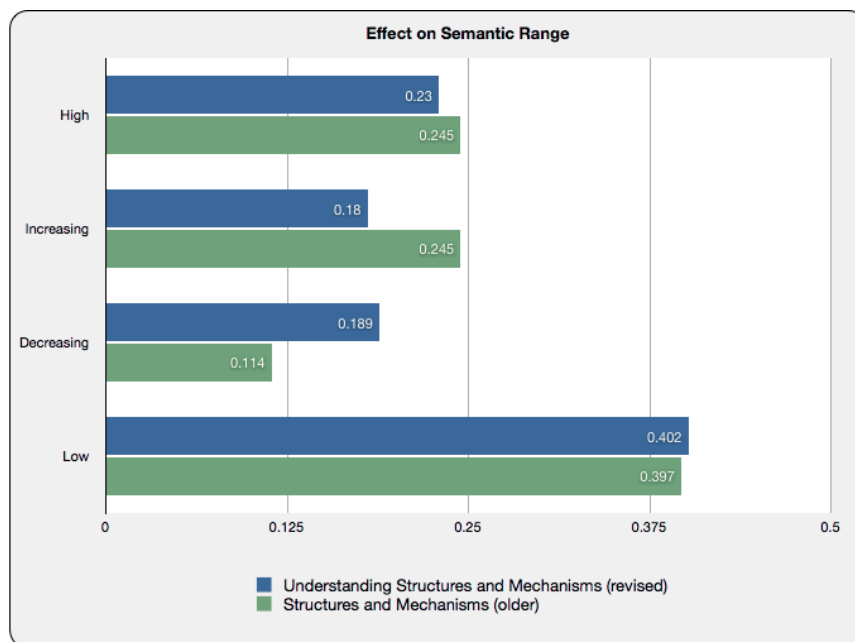


Figure 5.7: ESR comparison—Understanding Structures and Mechanisms (upper bar) versus Structures and Mechanisms (lower bar)
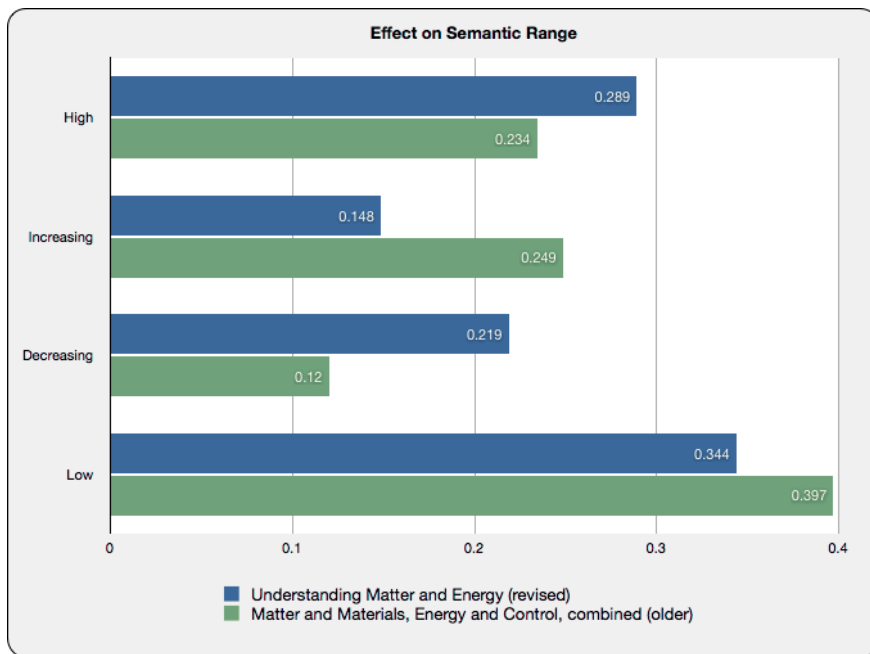
Figure 5.8: ESR comparison—Understanding Matter and Energy (upper bar) versus predecessor strands (lower bar)
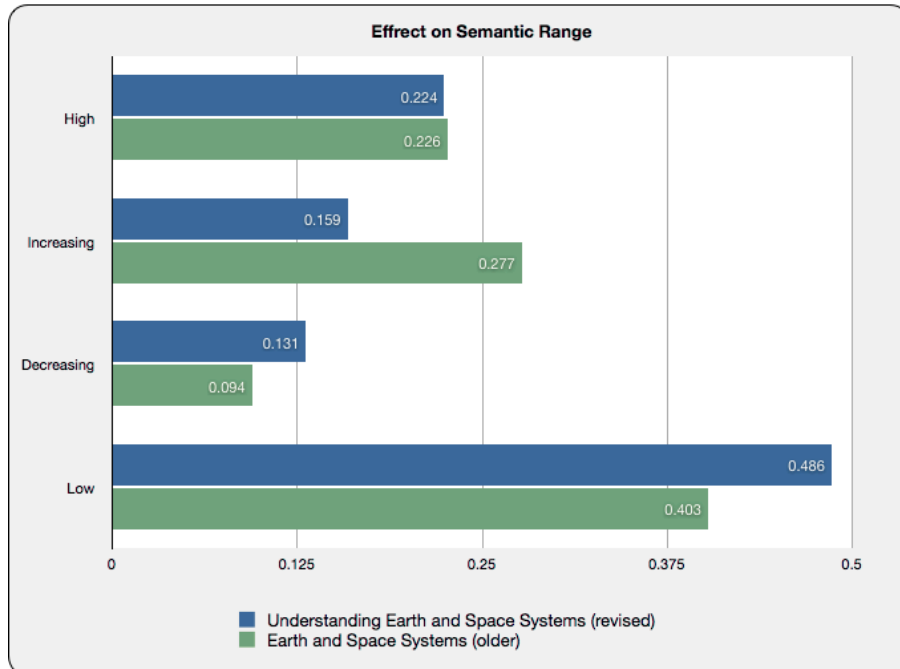


Figure 5.9: ESR comparison—Understanding Earth and Space Systems (upper bar) versus Earth and Space Systems (lower bar)

In comparing the graphs, perhaps the most recurrent difference lies in comparing the ESR increasing and decreasing code categories between the older and revised curricula. With the exception of the (Understanding) Life Systems strand, the revised curriculum has a greater proportion of its specific expectations whose effect is to decrease the semantic range, as compared to the older curriculum; correspondingly, the revised curriculum has fewer expectations which increase the semantic range as compared to the older one. These differences are consistent with the other observations regarding the nature of the curriculum reduction in that there has been an effort to increase 'relevance' and 'engagement' among the student audiences. Hence, more expectations have been reconfigured as means to demonstrate the applicability of scientific theories.

## 7. Effect on semantic range comparison—STSE/STW expectations

The ESR comparison between the older and revised curricula for the STW and STSE expectations reveal a great deal about the nature of the specific expectations for this section. The charts below present data in a similar manner to the previous section: counts for each code category are made for all units in each strand; the chart shows the proportion of each code as a fraction of the total number of expectations for each strand.
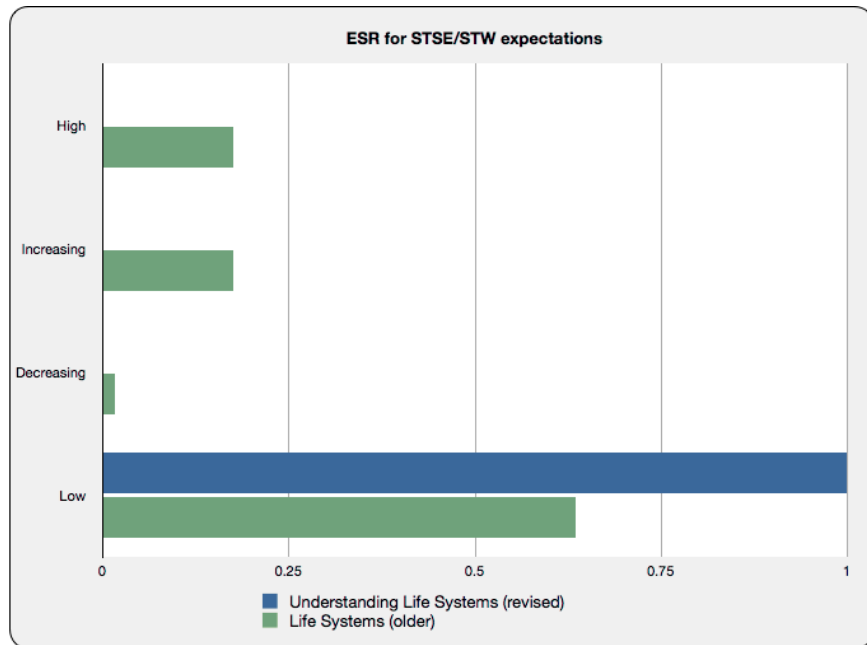
Figure 5.10: ESR comparison—Understanding Life systems (upper bar) versus Life Systems (lower bar). (STSE/STW expectations only)
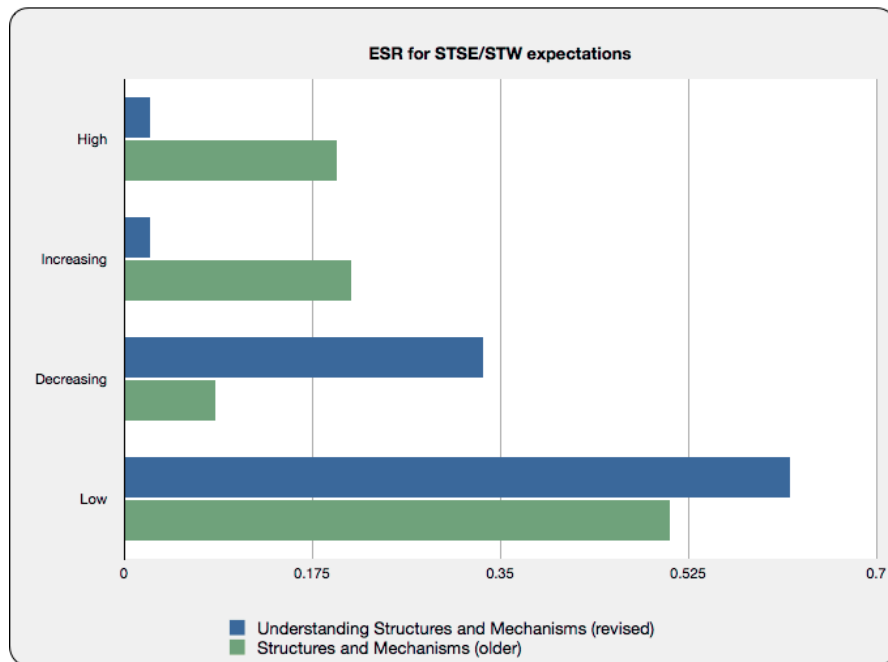


Figure 5.11: ESR comparison—Understanding Structures and Mechanisms (upper bar) versus Structures and Mechanisms (lower bar) (STSE/STW expectations only)
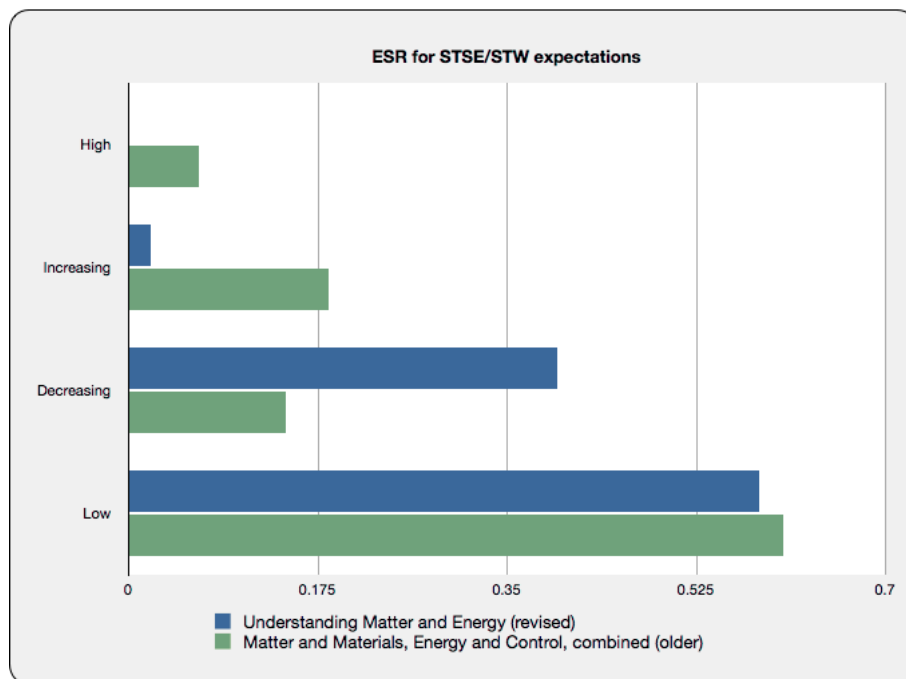
Figure 5.12: ESR comparison—Understanding Matter and Energy (upper bar) versus predecessor strands (lower bar) (STSE/STW expectations only)
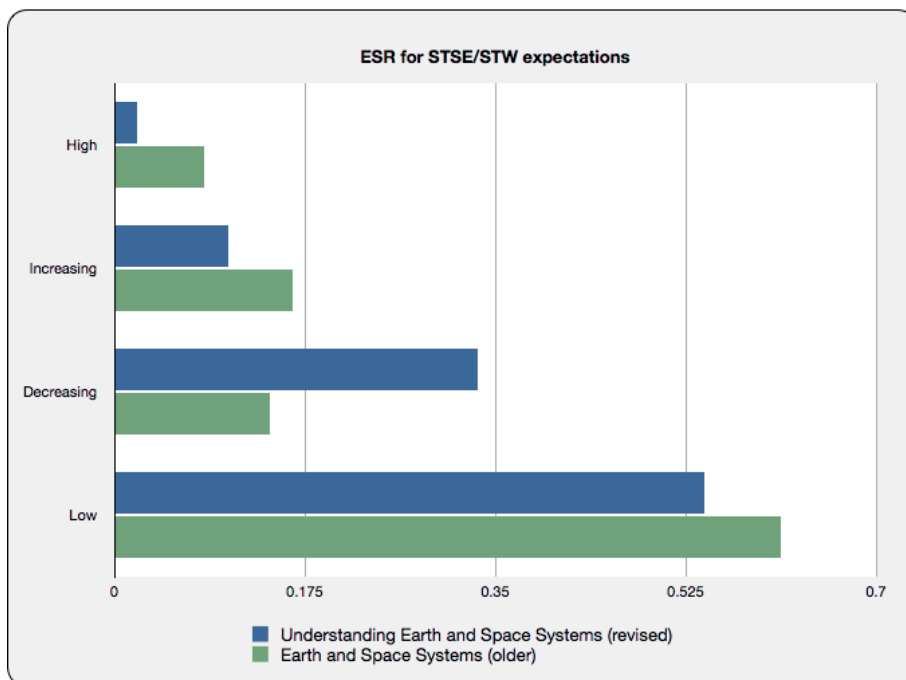


Figure 5.13: ESR comparison—Understanding Earth and Space Systems (upper bar) versus Earth and Space Systems (lower bar) (STSE/STW expectations only)

The ESR comparisons offer us a clearer picture of the nature of the STSE expectations that have been inserted into the revised curriculum. Predominantly, the STSE expectations offer fewer opportunities for elevating the semantic range as compared to knowledge objectives which focus on segmented propositional knowledge claims. In all strands, the code ESR 'low' form more than 50% of STSE expectations. The next most common type of STSE expectation is 'decreasing', in which the specific expectation facilitates a deductive learning process, pointing out examples of phenomena that illustrate more general theoretical propositions. ESR 'increasing' or 'high' could refer to objectives which are directed toward the development of general knowledge propositions in either scientific knowledge claims or in knowledges about societies and the environment. Almost uniformly in both curricula, the general principles were not of the latter form, but of the former; the knowledge in this section tended to generalize towards scientific principles. This is, of course, largely expected as the knowledge objectives here are for a science curriculum, not a sociological or environmental one. However, in comparing the revised and older curricula, the revised curricula makes little movement toward general principles. Instead, the STSE expectations often appear as marginally related environmental or societal knowledge attached to the scientific content by fiat. For example, consider the following expectations extracted from the revised curriculum:

> "By the end of Grade 6, students will assess the contributions of Canadians (e.g., astronauts Marc Garneau and Roberta Bondar; astronomers Richard Bond, David Levy, and Helen Hogg; Spar Aerospace Limited's development of the Canadarm; the University of British Columbia's development of the "Humble"space telescope to the exploration and scientific understanding of space"

> "By the end of Grade 6, students will assess the short- and long-term environmental effects of different ways of in which electricity is generated in Canada (e.g., hydro, thermal, nuclear, wind, solar), including the effect of each method on natural resources and living things in the environment"

The first expectation is from the *Understanding Earth and Space Systems* unit on *Space*, where the other expectations for the unit include: identification of components of the solar system, the distinction between luminant or reflective celestial objects, identification of technological tools of astronomy and space travel, celestial object positioning and its terrestrial effects. For the second expectation, from the *Understanding Matter and Energy* unit on *Electricity and Electrical Devices* the scientific content for that unit includes: designing and building electrochemical cells, designing and distinguishing between parallel and series electrical circuits, distinguishing between static and current electricity, explaining the functions of circuit components, and transformations between electrical and other forms of energy.

Here, we note that the *Space* expectation serves a purpose which can hardly be located within the realm of the scientific content. While it may be useful information that assists in 'nation-building', or rousing interest in learners towards the topic in general, such rationales could actually take the form of pedagogical decisions by the educator to contextualize content as she judged relevant within her professional discretion. Assigning such a content expectation either disparages the professional autonomy of teachers or devalues scientific knowledge by implicitly acknowledging such knowledge forms as of equal importance with, for example, the scientific explanations for tides, seasons, and other cosmological principles. For the *Electricity* expectation, while there is good case to be made for its inclusion in the unit, there is a sense that this expectation stands alone, not developing a general principle or demonstrating ability to be subsumed under a larger explanatory framework to achieve a cumulative modality across time.

## 8.      Conclusion

To conclude this comparison between the older and the revised curriculum, it is useful here to summarize the findings so far. A major source of the difference between the documents may be attributable to the simultaneous curriculum reduction and insertion of STSE content expectations. With curriculum reduction, there has been a concomitant loss of higher semantic range expectations of the form that might typically be labelled as difficult, abstract or lacking in application in everyday experience. The insertion of STSE content expectations has brought in content lower in the semantic range, with some of the expectations having only marginal relevance to the development of the scientific content. In comparing the older and revised curricula, it can be said that there is a general deprivileging of generally applicable scientific knowledge. Instead, in seeking to increase relevance, engagement, and a more widespread acceptance of the centrality and urgency of environmental issues, there is a sense that this has been achieved at a cost to the hierarchical development of principled scientific knowledge. STSE knowledge expectations primarily display stronger semantic gravity and weaker semantic density, which may be useful as knowledge expectations except for that they take a form that has varying degrees of disconnection to the scientific content of the unit. How these affordances and limitations of the revised curriculum are realized in classroom pedagogy will be studied in the next three chapters.

# Chapter 6
# Environmental dispositions and scientific knowledge

## 1.     Introduction

In this chapter, we study the case of Alice, a grade four teacher-librarian. In this elementary grade class, knowledge boundaries between scientific knowledge and other school knowledges were fairly weak, as evidenced by the use of literacy strategies to teach scientific content. At this grade level, Alice believed that a major task for schools was to introduce environmental issues to students, but as she believed that knowledge was not as important as the 'big ideas' that students retain long after they forgotten the specific 'facts', a major consequence of this consideration is that her lessons often resulted in an inculcation of a sense of moral panic over the state of the environment. This issue appears to be fundamental to typical approaches of environmental education and is a recognized issue among environmental educators.

## 2.     Alice: Grade 4 teacher-librarian

Alice has had eight years of teaching experience, although she felt that teaching is in her blood. Her parents were both teachers, and when she was younger, she had helped out her parents by supply teaching when one of her parents was not able to go to school. She admired her father for his ability to possess a commanding presence; he was not particularly harsh or disciplinarian, but whenever he appeared in the classroom, students instinctively sat up and were ready to pay attention to him. She had a science background, having gone through some effort to graduate with a science degree despite her grandparents (who still live in a rural, farming context) not understanding why girls needed that much education. She worked in a pharmaceutical business for ten years

until the franchise was sold, and then she took up a job at the local library for three years. While a librarian, she took charge of many of the outreach and teaching efforts, leading colleagues to remark that she was a natural teacher. She took up the challenge and joined the teaching profession, and has been teaching since. She thinks of schooling as a community focal point, a place where students come to learn the social norms and participate in the building of cultural practices. It would be safe to say that she would probably disagree with some of the more radical perspectives toward social change, instead preferring that school remain neutral with regard to social issues. In her school, which is in a low to middle class section of the city, there is a large number of children of immigrant parents. However, the class which we used for our study was one of her better ones, the French immersion students who were generally regarded as being academically talented and well behaved. With regards to her approach to content mastery, she expressed that she was not as interested in her students' grades as their "work ethic, work habits and teaching the kids the skills they need to go through the different grades."

As she was the teacher librarian, she had to remain in the library in case her services were needed. On a number of occasions, teachers from other classes would send a student down to seek her assistance in finding some resources for a topic they were teaching. This caused her no end to her consternation, as she had reminded staff during meetings that they were supposed to give her at least twenty four hour notice for her to render assistance. She would consciously delay her response to the request, getting the errand-running student to wait as she got her lesson to a comfortable location for a pause. The physical premises of her 'classroom' was also not ideal, as it was a simple large, rectangular room that was divided into two sections with bookshelves in the middle. On one side was her 'classroom', and on the other was a computer lab. This computer lab was al-

most always filled with students, often working on individual research, which meant that the noise level was quite high. The bookshelves served very poorly as a room divider; not only were the shelves low, they were aligned such that their lengths were parallel to the length of the room to "maintain sight lines". As a result, she was often in contest with the other class for the attention of her students. Even so, she managed to maintain an even temper despite these disruptions and distractions, never raising her voice; her students picked up on this and correspondingly were generally well behaved and cooperative.

As the periods for this school was only thirty minutes long, with a double period once a week, this often meant that activities were cut short, and had to be restarted again at the next period. This frequent shutdown-startup took its toll on the amount of time students actually had to do real work. Outside of her classroom, however, she managed the school's 'E Team', an environmental club, whose activities included a energy audit (finding out which classrooms had left their lights on during recess), waste audit, and a public outreach activity where students danced to the song "It's our world" during a school assembly:

All right cadets, recite the E team pledge with me:
[chorus]: We the members of the E team
in order to form a more perfect union with the earth
establish source separation of yucky garbage
insure the biodegradability of domestic cleaners
provide for the defence of common groundwater
promote the general compost pile
and secure the blessings of low energy consumption
to ourselves and our families
Do ordain and establish this organization
for the betterment
OF OUR WORLD!
Congratulations to our new inductees,
you are now officially members of the E Team!
[music begins]
It's our world,
and we'll do what we can to be part of the plan
It's our world,
and it's wasting away, we've got to stop or we'll pay
It's our world,
and we got to save it now!
It's our world, [chorus: It's our world]
The challenge is ours, we're earth saving stars
It's our world [chorus: It's our world]
We're taking control, a leadership role
It's our world [chorus: our world]
and we got to start right now

We'll use less and save more
recycle and re-store
buy things that're friendly
It's more than just trendy
It's our world
It's our world
and we'll do what we can to be part of the plan
It's our world
and it's wasting away, we've got to stop or we'll pay
It's our world,
and we got to save it now!
It's our world, [chorus: It's our world]

The challenge is ours, we're earth saving stars
It's our world [chorus: It's our world]
We're taking control, a leadership role
It's our world [chorus: our world]
and we got to start right now
We'll use less and save more
recycle and re-store
buy things that're friendly
It's more than just trendy
It's our world
It's our world, our world!

While this activity may not have been representative of the environmental club activities, there is nonetheless a dimension of concern to this activity in the way that the song contains elements which could equally well be used in other less educative procedures—the phrase "it's our world" is repeated twenty-two times throughout the brief song; there are hints of religious imagery ("blessings", "ordain", the concept of hell: "we've got to stop or we'll pay"); and the song has a fast-paced tempo about the same beat rate as a typical (child's) heart rate. On one level, one may argue that this choice of music is perfectly innocent; in fact, it might even be desirable for children to be left with a strong memory of the phrase "It's our world" (and therefore we should do something about it). Further, the choice may have been made on totally innocuous grounds that a fast-paced tune was needed for the children to dance to. However, while I am not attributing any untoward intent towards Alice's selection of music, the existence, and most likely, popularity[23] of such music circulating among school teacher networks concerned with spreading the environmental message is

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23. The music was on a mass-produced CD. While music recording and publishing prices have fallen significantly in recent times, such productions are nonetheless not casual ventures, and require some degree of mass purchase to justify the investment.

a point of concern from the perspective of understanding education as a means to expand on the realm of possible action, and increasing understanding and critical consciousness.

To be fair, studying the conduct of student environmental clubs was not a major concern of this study, and this encounter was unintentional. However, the fact remains that Alice was proud enough of her, and her students', efforts to raise the level of environmental awareness in the school that she often spoke to me about it. In addition, and more significantly, this vignette serves as a means to prefigure the substantive point for this chapter—efforts to raise environmental awareness in young children often involve rousing their sense of justice at alleged tragic circumstances of environmental degradation. We look here at what may be consequences of such an approach.

### 3.    Teacher perspectives

Recall that a major contemporary perspective for environmental and STSE education is the centrality of action—that students need to have experiences in taking meaningful steps towards the resolution of environmental issues within their direct spheres of influence. While the revised elementary curriculum document does not prescribe action as a central focus, there nonetheless exists assessment criteria for the category of knowledge application that measure students' performance in "proposing courses of practical action to deal with problems relating to science, technology, society, and the environment" (p. 24). In addition, the Alice and Bob were formerly participants of a professional learning community, which had as one of its emphases the practical implementation of action in the science classroom. Clara attended graduate courses with similar emphases, so all three participants had a thorough grounding in the significance of action in the science classroom. In fact, Alice and Bob were members of team efforts to design and implement an action-related classroom lesson during the PLC. As part of the rationale for visiting their classrooms, Alice and

Bob were asked to implement the curriculum projects that they had worked at the PLC. As such, the observation that her class did not engage in any form of action required some explanation. I had enquired about her opinion on the role schools played in society, she had responded that she felt that schools were better described as community organizations that were responsible for transmitting social norms, instead of places for the amelioration of social injustice:

> I think schools have to be like a centrepiece of the community [...] It's such a communal place [...] I think the main role of a school is the [development of] rapport between the home, the school, and the children. Because I think that as a school, our job is to get those kids ready to be out in the community, in jobs, in whatever role they're going to be in the community [...] I think the role of the school is that of community liaison.

In her opinion, the concept of social activism or action directed at sociopolitical amelioration was largely a foreign concept for her colleagues and herself:

> I don't necessarily see this [sociopolitical action] in our schools, or in teachers that I talk to. Because, they ask how are you teaching this, that's why I do workshops and I've gone to other schools, and I go out to other schools and stuff, and I see "oh that's a really good idea" but I wouldn't have thought of doing it that way. And I think that's part of the issue too. People who are teaching this way, have to get out there and let people know, and give them some ideas of how to do it, or otherwise you get stuck with that not so much the skills based teaching that I like, but the content, again.

Alice's goals for the unit was for her students to gain some awareness of issues, not so much for them to become involved in socio-political debates and associated action or activism. She remarked that she had been a long-time advocate for more opportunities for her students to learn about the environment, especially through the use of the immediate outdoor environment outside of the school. This tendency earned her the local reputation as the "Outdoor Teacher", but also generated friction with a previous school principal who did not agree completely with her methods:

> I've always been a big believer of it, but there have been different administrators, where it hasn't been encouraged. It's actually kind of nice that the new curriculum matches my philosophies more. I've always ended up tailoring my lessons to whatever the ad-

> ministration wants. This school is great because the administration lets you, not, not do what you want, but I pretty much have free rein on my programming, provided that you're meeting the expectations and the kids needs [...] I was referring to one specific principal in one specific school I was in for 2 years, and they didn't want you going outside. They didn't even encourage trips. Which, with these guys [her current students] I'm actually taking them to an OEC [Outdoor Education Centre] in June. I believe **strongly** in Outdoor Education. So, as I said, in different schools, there has always been different philosophies and different beliefs about it. And I'm finding now, that in the new curriculum, there is so much more emphasis on it, that it's great, cos it matches my philosophy. Because, before, I didn't always find that. And when I found that some principals didn't encourage it, like "what are you doing out there again?" That's the type of attitude I had. Whereas like, here, it's great, I guess I haven't had any issues.

The combination of a supportive school administration and a curriculum document which privileged learning about the environment allowed Alice opportunities to pursue the kind of pedagogy that she preferred. Unfortunately, during the observation period, which occurred over the course of winter, her class only went outdoors on the school yard for one session, in spring when it was comfortable to be outside without warm clothing.

### 6.3.1 Goals for science education

Alice described her lesson planning heuristic: she considered the list of expectations for the unit, and decided first on the choice of expectations that needed her particular attention for reporting on at the end of the year. Closer to the implementation period, she takes into consideration current environmental issues, and draws upon one with particular topical interest, and then considers the scientific content learning that may be derived from that issue. For her, even though the specific expectations in the curriculum document examined the interaction of science and technology with societies and the environment, she had interpreted these changes in primarily the environmental aspect of science education:

> But I think the new curriculum really has influenced what I teach, because I really focus on that environmental component, how do humans interact with the environment and with nature, because that basically can come into all of your science units, right? In some way or another.

Alice was not particularly interested that her students retained the knowledges of science, which she referred to as 'content':

> I want something that kids can transfer, because they don't necessarily remember content, especially at this young age, they're not going to remember the content, *per se*, [...] so I was really excited when the new curriculum listed the skills first. They want them to have the research, and the inquiry, those are the skills that can transfer to any unit, and not just whatever that I'm teaching.

These skills that she spoke of were generic skills, for example, research skills, web and print search strategies; and general dispositions of intellectual curiosity, tenacity, and environmental dispositions: a concern for the environment and an appreciation for natural spaces and the outdoors. Perhaps echoing the discourse of Wiggins and McTighe (2005), she asserted the importance of 'big ideas' that would be retained long after the lessons were over. Reflecting a certain degree of ambivalence toward the importance of knowledge, in a later interview, she acknowledged the importance of 'content':

> And yet, you know what, I do agree the content is important, I'm not advocating that the content is not important, because I think it is, but I think we need to remember that kids at a certain age can learn certain things, and I think we need to work on those certain skills, so that they can transfer to another subject or another year, or whatever.

While observing her lessons, this perspective did find expression in the way that Alice tended not to have an explicit focus toward the development of specific content knowledge goals. For instance, one possible (albeit uninspired) way to develop the idea of structural adaptations (expectation 3.7) would be to point out specific instances where adaptations were occurring, and then dis-

cuss the idea of adaptations in general. Because of the way she approached instruction, packaging multiple learning objectives into a set of activities underpinned by a central narrative theme (e.g. *Kapok Tree*), there was little by way of discrete, direct instruction in the way described above. This pedagogical style effectively communicates the centrality of the environmental issue, and serves as a potential model for the development of environment-related science pedagogy. However, while not an inherent limitation of this pedagogy in general, her class did not engage deeply with the milieux of scientific practice—there were no practical investigations, for example, even though an activity was suggested in the curriculum document. In addition, discussion of ontology and epistemology was not a major focus of her classroom; here these goals are not particularly ambitious, only taking up Matthews' (1998) call for modest goals of simply "slowing down the lesson" and "asking the philosopher's standard questions: What do you mean by …? How do you know…?" (p. 168).

### 6.3.2 Curriculum document affordances/limitations

In terms of changes that she made to her pedagogy with the onset of revisions to the science curriculum, Alice claimed that she required little adjustment, as she had already been practising aspects of the new curriculum:

> What has changed is that what I've done in the past is now validated by it [the new curriculum]. And now I actually spend more time on it [environmental/outdoor pedagogies]. Where I would have just talked about it a little bit, it wouldn't have been necessarily the focus of a lesson. Whereas now I find that it's much more of a focus.

Because Alice was preparing to assume a leadership position in the school system, and because she had some seniority within her community, she had access to teacher demonstration/sharing and co-teaching efforts within her local cluster of schools. While this viewpoint may be not without bias, there is an inclination here to accept her observations of the typical teaching situation as largely accurate due to her long experience as a teacher in her local context. In any case, in lieu of

an actual large scale study, I had asked her to give her subjective interpretation of the state STSE/ environmental education in science classrooms. She responded that, for the most part, her style of pedagogy that blended science with environmental education was not common; she mentioned once that:

> I've always taught that way. But I always thought that I was a pioneer, because other teachers go "we don't teach like that". And I go, "heh, ok, I know".

In contrast, many teachers would still extract lessons and activities from textbooks and curriculum material provided by the school board, instead of creating lessons "from scratch" as she did. This often took the form of her locating articles of topical interest from newspapers, and inventing activities around it. I asked her if she thought that designing lessons with an media-/critical- literacy emphasis would lead to a loss of scientific content knowledge; she replied:

> It's possible, that's where the balancing is really hard. And that's what I think teachers are struggling with—these new curriculum expectations. [...] I've talked to many teachers, and a lot of teachers are teaching the old way. They're not really incorporating environmental stuff in there, too much. [...] We're trying here, as I said, because of the Eco-Schools stuff, and because we keep giving stuff to teachers and hoping that people do stuff. But, whether they do it or not is another issue. So, it is easier to teach content than teach stuff like this.

The curriculum document actively hints at certain textbooks: for example, for specific expectation 1.2 (reasons for depletion or extinction of plant or animal species), a suggested issue reads:

> Deforestation for land development, as well as hunting, trapping, and increased tourism, have had an impact on the wolf population in Ontario. Despite recent laws designed to protect them, wolves in Ontario still face many threats. What other animals and plants would be affected by their destruction, and what can we do to help them survive?

This sample issue appears designed specifically for the story of *Wolf Island*. It is likely that curriculum writers for the ministry document may have been successful elementary school teachers

themselves, and have had prior positive experiences with this book in their classroom, hence the suggestion.

## 4.    Curriculum overview

For Alice's grade 4 class, the unit that was observed was from the strand entitled "Understanding Life Systems". The unit title was *Habitats and Communities*. Alice's grade 4 class had science lessons 3 sessions per week, a double period (1 hour) and two single periods (45 minutes each). When observations started in her classroom, she had just started on the unit, and I was present through the approximately eleven weeks it took for her to complete the unit. However, although there were a possible total of 33 lessons to study, only nine lessons were recorded as the research focus at that time was on the conduct of environmental education related science lessons, and I took one week away to attend a conference. Because there were several periods that were lost to school activities (e.g. the annual book fair), and some of the lessons near the end of the term were 'fillers' where unimportant work was assigned to students, these nine lessons still provided a fair sampling of the pedagogical activities utilized for this unit. The older and revised specific expectations for the unit are compared in the table below. Equivalent expectations are not tabulated, the following table lists the differences between the curricula.

| Older curriculum (1998) | Revised curriculum (2007) | Comments |
|---|---|---|
| identify, through observation, various factors that affect plants and animals in a specific habitat | identify factors that affect the ability of plants and animals to survive in a specific habitat. | "through observations" missing in the revised curriculum, suggesting that practical investigations are no longer important. Changing language from the more general "affect plants and animals" to "affect the ability [...] to survive" reflects a desire to pose the issue in more dire terms than actually necessary |

| | | |
|---|---|---|
| demonstrate structural adaptations of plants and animals that demonstrate a response of the living things to their environment | describe structural adaptations that allow plants and animals to survive in specific habitats | as above, 'survive' is used to pose the issue in more dire terms. |
| recognize that animals and plants live in specific habitats because they are dependent on those habitats and have adapted to them | explain why changes in the environment have a greater impact on specialized species than on generalized species | more sensationalistic phrasing |
| classify plants and animals that they have observed in local habitats according to similarities and differences | expectation deleted. | foundational taxonomical principle missing, moved to grade 6 Biodiversity unit. |
| describe ways in which humans are dependent on plants and animals<br><br>and<br><br>describe ways in which humans can affect the natural world | analyse the positive and negative impacts of human interactions with natural habitats and communities (e.g., human dependence on natural materials), taking different perspectives into account (e.g., the perspectives of a housing developer, a family in need of housing, an ecologist), and evaluate ways of minimizing the negative impacts. | 'affect' versus 'impact'—more evidence of use of charged language |
| investigate ways in which the extinction of a plant or animal species affects the rest of the natural community and humans | identify reasons for the depletion or extinction of a plant or animal species, evaluate the impacts on the rest of the natural community, and propose possible actions for preventing such depletions or extinctions from happening. | again, use of 'impact' instead of 'affect'; but additional expectation for students to 'identify reasons for depletion or extinction' is a useful addition. |
| not in older curriculum | use scientific inquiry/research skills (see page 15) to create a living habitat containing a community, and describe and record changes in the community over time. | useful practical activity. |
| not in older curriculum | demonstrate an understanding of why all habitats have limits to the number of plants and animals they can support | |
| not in older curriculum | describe ways in which humans are dependent on natural habitats and communities (e.g., for water, medicine, flood control in wetlands, leisure activities) | pro-environmental message |

Table 6.1: Curriculum comparison, Grade 4. Strand title: Life Systems/Understanding Life Systems

A comparison of the two curricula reveals the strong influence of the environmental education agenda. As evident, this consisted of bringing attention specifically to human 'impacts' on the natural environment, and inflating the importance and direness of these effects. While it is important to underline the importance and urgency of environmental issues, the revised curriculum may have gone beyond what may be safely classified as the middle ground between sensationalism, and downplaying environmental issues.

## 5.    Semantic profile

A typical lesson in Alice's class would start off with her reading a story to the children seated at the front of her segment of the library where she conducted her lessons, followed by her setting a task for the students. For example, she would read them the story of The Great Kapok Tree, where a woodcutter went into the (Amazonian) rainforest intending to cut down trees, but takes a nap instead, and the various animals whisper into his ear reasons why he should not cut the tree down. He wakes up, suddenly realizing the truths of the whispered messages, and changes his mind, walking away to a happily-ever-after conclusion. What followed would be an IRE (Initiate-Respond-Evaluate) question and answer time for her to gauge her students' understanding of the story, and then her students were assigned tasks related to the story they just read. While the story was still fresh in the heads of the children, Alice asked them to form groups of three, and in those groups, prepare and act out a scene from the book. Then, for this topic, students were asked to practice their research skills by finding facts (as opposed to opinions) from books about rainforests. These facts would be written onto leaf shaped cutouts, which were then coloured and attached on

another piece of paper to resemble a tree branch. Her additional requirement for the students was that they needed at least two facts where humans were either positively or negatively affecting the environment. Because this was an elementary grade class, there were skills and knowledges besides the scientific that were important to convey to the students, and 'integration' was a common pedagogical strategy. In consideration of these demands, lessons often contained activities like literacy practices, for example, preparing and acting the skit, and reading books to students.

Overall, Alice's observed lessons varied in semantic range with an appropriate mix of activity as described above. The story telling activity was a good means of directly introducing the empirical phenomena to the students, and were coded as stronger semantic gravity (because the stories were about contexts which were described with the aid of pictures in a book and had themes that were familiar to students of that age), weaker semantic density (because the stories were introductory in nature, few complex words were used). The effect of this activity of story-telling was to increase the semantic range, because the stories themselves were directed toward the transmission of strong moral messages which by themselves were the point of the narrative. For example, in the story of *The Great Kapok Tree*, the message was that a great many plants and animals depended on the Kapok Tree for various needs, which was specific expectation 1.1. For the story of *Wolf Island*, where the top species departed from an island, causing the collapse of the local ecosystem, the message was that of specific expectation 1.2. In the book *Why Should I Protect Nature*, the message was clear and direct, repeated throughout the story—that a vastly degraded natural environment was the consequence of little uncaring actions.

Besides lecture-style story telling (Alice preferred to read the story with minimal interruption for IRE style checking of comprehension), Alice also conducted some phases at the end of student

activity, or bookended the story-telling time with IRE whole-class discussion, with the students gathered on the floor near her chair. These sessions were rather useful, with weaker semantic gravity and stronger semantic density, alternately: (i) introducing a high-level idea by connecting it with a previously learnt idea (ESR: high); (ii) or summarizing the learning that was supposed to have happened during the activity (ESR: decreasing); or (iii) pointing out the general principle from the foregoing ideas introduced (ESR: increasing). For example, during a whole-class IRE discussion review of the story of *The Great Kapok Tree*, this conversation transpired:

> T: What else? Samantha?
>
> Samantha: It's really warm and hot and humid in a rainforest.
>
> T: Ok. I want to show you this map here at the beginning [of this book] and [.] you can see that there are rainforests throughout the whole world, basically. Except for North America which does not have rainforests.
>
> T: Ok, the green represents the rainforests. Can you see a pattern happening here? Where are the majority of the rainforests located? Anybody know what this is called? What's that? Sarah?
>
> Sarah: The equator?
>
> T: The equator! Right, so, if you look here you can see the big sections of the rainforests are where the equator is, where it's really hot. ok.

As a pedagogical strategy, this was particularly useful in encouraging students to inductively generalize from the the individual ideas learnt onto larger principles. However, IRE is not uniformly optimum for increasing or decreasing the semantic range of the lesson. There were instances where Alice's IRE changed to a "Guess what's in my head" style of IRE, as when she was issuing general instructions for creating a mind-map, for different ecosystems around the world:

> T: [what about the] Arctic?
>
> Student: Cold and windy
>
> T: You could do that in one bubble [fill that in as a node in a mindmap]. Actually, what would you call that? Cold and windy, what would you call that? Ahmed?

Ahmed: Frozen?

T: [to another student] Ok, what would you call that?

Student: [inaudible]

T: Not always, ok, you could even call it something [like] climate, or you could call it weather patterns, you could call it [...] That's what we're going to do, We're going to brainstorm not only for the subheadings. Say, you can put the Arctic as your subheading there, then you could put in this bubble, climate, ok [...]

This style of IRE interaction served mainly to check comprehension, slow the pace of the knowledge acquisition to a point where teacher was convinced everybody was keeping up, and to make sure everyone was paying attention by directing questions to particular students (e.g. Ahmed) who may appear to not be paying attention.

Being a grade 4 class, there was little to no homework or project work assigned to these students. Instead, all of the work was done in class, typically in groups or at least in pairs, and these activities tended to take far longer than the time she assigned for the students, for example, she announced that the students had "10 minutes" to prepare for a presentation, but by the time she called the class to order, 25 minutes had elapsed. There were also several lessons where these group activities were allowed to proceed till the end of the period, with no summative discussion or lecture to round off the learning for the session. The activities for the students during these sessions were generally of weaker semantic gravity, as they were working with concepts that were relatively distant from their immediate contextual experiences, and relatively strong semantic density as they had to use 'big words'. Examples of such activity included the session where they had to roleplay being stranded on an island for a year, and thus decide what items to bring (ESR: decreasing); extract ideas from the story of *Wolf Island* to connect with other ideas from what the students have previously encountered (ESR: increasing); extract 'facts' from the books they were distributed

about the nature of the ecosystem that they had selected (ESR: increasing); create a mind-map of the characteristics different ecosystems around the world (ESR: increasing); and collecting facts about how humans are positively or negatively affecting the rainforests (ESR: increasing). Again, not every classroom activity was classified similarly. In the minority were activities like preparing for a skit (SG+, SD–, ESR low), or preparation for a presentation (SG+, SD–, ESR low). These activities were were not demanding for the students, and were assigned when Alice seemed to want a break from the usual teaching sequence. This was especially the case in the last lesson of the term before spring break—she assigned an art activity because "I thought we should do something more fun and more creative for our last day before the break".

Of the specific objectives listed in the curriculum document, it is worth noting that several of them were not observed, either as a consequence of my absence from sessions throughout the unit, or because I had communicated to Alice that I was interested in the lessons where she was teaching environmental education. To reiterate an earlier point, this was because of a theoretical framework that had been revised after the data was collected. Significant expectations not observed include: 2.4 (Create a living habitat), and 3.7 (Structural adaptations). Given that these were significant ideas and activities that would have taken a considerable amount of time to communicate to the students and implement in the classroom, and that my absence from her classroom was sporadic and not over an entire block of time, it is likely that these concepts were actually not taught in her class. Implications of these observations will be discussed later.

A table recounting the semantic range of the phases for a series of lessons is presented below:

| Lesson/Phase | Description | Coding/Comments |
|---|---|---|
| | Lesson 1 | |

| Phase 1 | IRE discussion: recounting main themes from previous lesson | SG–/SD+/ESR: Increasing: Recounting specific instances of major ideas and pointing out how they may be subsumed under a general organizing principle. |
|---|---|---|
| Phase 2 | Lecture: Alice introduces the 'big words' for the term, 'ecosystems', 'habitats', 'human impact', etc. | SG–/SD+/ESR: High: introduction to high complexity terms that will be used in this unit. |
| Phase 3 | group work: In groups, students brainstorm on the items they will bring if they were to be marooned on an island for a year. | SG–/SD+/ESR: decreasing: students work from general principles of survival to judge whether individual items will be essential for their stay |
| Phase 4 | Summary lecture: Alice calls the class to oder to summarize the work that the class has done so far. | SG+/SD–/ESR: Increasing: intellectually powerful move by Alice to encourage students' meta-analytic and reflective abilities. |

Lesson 2

| Phase 1 | Lecture/IRE discussion: Alice reviews the work that she has seen groups produce, and directs students towards the goal that she has in mind. Groups in line get praised while other groups get guidance | SG–/SD+/ESR: Decreasing: Alice refers to quality criteria, and points out where various groups are meeting/not meeting these standards. |
|---|---|---|
| Phase 2 | Group work: groups continue working on their projects to put together a presentation | SG+/SD–/ESR: low: Students work on presentation details. |
| Phase 3 | Group presentations: Group come forward in turn to read off the items they planned to carry with them to the island | SG+/SD–/ESR: low: students speak about their work to the class. |
| Phase 4 | Summary lecture: Alice gathers the class and reviews the lesson. | SG+/SD–/ESR: Increasing: Alice highlights some general principles during this phase. |

Lesson 3

| Phase 1 | Lecture/IRE discussion: Alice links the activity with the story of *Wolf Island* told before the activity. | SG–/SD+/ESR: High: Alice is linking abstracted elements from both activities together. |
|---|---|---|
| Phase 2 | Group work: Worksheet activity on making connections | SG+/SD–/ESR: Increasing: Students work on linking multiple concepts together in a meaningful fashion. Lesson ends while students are still working |

Lesson 4

| Phase 1 | Classroom management: Entire grade level is held back at recess for not knowing how to assemble quietly. | –NA– |
|---------|------------------------------------------------------|------|
| Phase 2 | Lecture (Story telling): Alice reads the story of *The Great Kapok Tree*. | SG+/SD–/ESR: increasing: story attempts to convey a general principle (don't cut down trees) via highly contextualized story |
| Phase 3 | Group work: in groups, students prepare a short skit | SG+/SD–/ESR: decreasing: students are busy with the aesthetic aspects of the skit–translating emotive aspects of the story into action. |
| Phase 4 | Presentations: Students act out their short skits. | SG+/SD–/ESR: low: as students act, others participate as audience members. |

<div align="center">Lesson 5</div>

| Phase 1 | Lecture (Story telling): Alice reads the book *Why should I protect Nature?* | SG+/SD–/ESR: Increasing: Book develops the general principle of why students need to protect nature. |
|---------|------------------------------------------------------|------|
| Phase 2 | Pair work: Students work on worksheet activity together | SG–/SD+/ESR: Increasing: Activity develops general principles for scientific content. |

<div align="center">Lesson 6</div>

| Phase 1 | Lecture: Alice introduces a book on aquatic habitats | SG–/SD+/ESR: High: Non-fiction book filled with pictures of exotic aquatic habitats and their features |
|---------|------------------------------------------------------|------|
| Phase 2 | Individual seatwork: 'downtime' activity as this is the last period before the March break, students work on art related project | SG+/SD–/ESR: low: No conceptual development for this period. |

<div align="center">Lesson 7</div>

| Phase 1 | IRE discussion: Review of *Kapok Tree*. | SG–/SD+/ESR: Increasing: Generalizing details of story to develop abstract principles. |
|---------|------------------------------------------------------|------|
| Phase 2 | Group work: Students extract 'facts' from books and write them on paper 'leafs' which are then stuck onto a 'tree'. | SG–/SD+/ESR: increasing: students gathering diverse knowledge propositions together to form some semblance of an ordered set |

<div align="center">Lesson 8</div>

| Phase 1 | Instructions/book reading: Students read books arrayed throughout the library, looking out for tropical rainforests and other concepts. | SG–/SD+/ESR: Increasing: students have to gather information from diverse sources, summarizing knowledge from diverse sources |
|---------|------------------------------------------------------|------|

| Phase 2 | IRE discussion: Alice discusses with the class what they have found so far | SG+/SD−/ESR: Increasing: Through the discussion, Alice summarizes the findings and points out general ideas. |
| Phase 3 | Individual seatwork: mindmapping activity | SG−/SD+/ESR: Increasing: Students work on producing mindmaps. |

Table 6.2: Coding summary for Alice's classes

In summary, the semantic profile for Alice's class follows a wave-like progression through most of her individual lessons, with an introduction high on the semantic range, followed by activities which allow students to work with the ideas introduced in the beginning of the lesson. Alice would then conclude by summarizing the work done and reminding students of the general principle. These activities were all typical and expected of what experienced and highly competent teachers are capable of. Because there were not enough lesson observations for Alice's class, the overall development of the semantic profile of her lessons through the eleven weeks was inconclusive.

### 6.5.1 Integration

As Alice was teaching a grade four elementary class, the strength of classification between the knowledge types in her classroom was fairly weak, in the sense that there did not appear to be discrete knowledge boundaries between the different knowledges being transmitted in class. Book reading, which may be considered one of the cornerstones of literacy practice at the early elementary grades, was interspersed with science content and elements of drama (e.g. the short skit for *The Great Kapok Tree*). More significant than the classification of knowledge forms between the traditional knowledge boundaries in school, in Alice's lessons, there appears to be a relatively seamless integration of environmental and scientific knowledge, something that is not found in the later grades as I will detail later. This is in contrast to what might be expected from the analysis of the

revised curriculum, where the environmental content stood in tangential relation to the scientific content.

This integration takes the form of her using fiction books that appear to be have been the exemplars that the curriculum writers had in mind when they wrote the curriculum. For example, *Kapok Tree* was first published in 1990, and has been a popular book with North American school teachers, and it is not unexpected that curriculum writers, often themselves having been school teachers, would design curriculum expectations in such a way as to implicitly recommend certain publications, these publications having become akin to de-facto textbooks to convey certain concepts. In concert with these books which convey environmental messages (of the ethicality and urgent need for conservation), Alice would use the context provided by the story as a means to explore scientific ideas generated around the context, often in practices which encouraged the students to use their imagination, and also in combination with additional material that she would provide. For example, the telling of the story of *Wolf Island* led to her activity of getting students to plan for a year long stay on an island, and then to her analogy of the Earth as such an island floating in space, and therefore the need to not disrupt ecosystems in general.

## 6.     Discussion

Because the theoretical framework of this study was modified after the data collection, there may be insufficient grounds for making well supported claims using all the theoretical concepts introduced in the review chapters. In this regard, the following discussion (and the discussion sections of the other cases) should be interpreted as exploratory theory generation, and not conclusive statements of truth claims supported by an elaborate latticework of evidence. It is not as though

evidence for these claims do not exist, but rather that the support for these claims would be stronger if the data collection had proceeded with the revised theoretical framework in mind.

Considering the lesson content of Alice's lessons as summarized in Table 6.2, there is evidence for supporting Alice's claim of being a masterful 'integrator' of knowledge forms throughout the elementary curriculum—specifically, Alice's lessons were such a blend of literacy (e.g. reading, fact collection, writing, skit work) and science knowledge (knowledge of biomes, ecosystem interdependencies, human interactions with ecosystems) that it was often hard to tell if a science lesson was actually going on—certainly there were none of the stereotypical activities that marked lessons as being science: no laboratory to speak of, no teacher in white lab coat, no 'experiments'[24]. In other words, there was a relatively weak classification of space, time and discourse in Alice's class: the class did not need special facilities to be conducted in; lesson progression was not strictly enforced (the three books could have been introduced in any order); and the lesson discourses contained implicit rules for the recognition of legitimate texts. Contributory to her ability to conduct her class in this manner was the degree of autonomy that she enjoyed. Alice was a well respected member of the school, the grade 4 class had no standardized testing for the year, and the principal had given her a largely free rein in her classroom:

> [...] and that's why I said it all depends on whether your administration was supportive or not. Sometimes I would tailor my lessons to what are more traditional lessons, because that's what I though the principal wants to see, though not necessarily how I would normally teach it. But here, with this administration, you have a lot of freedom in how you deliver your program. And I'm finding that the program is working really well.

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24. To be sure, these were not required for the unit they were studying

These circumstances offer us some insight into curriculum making: specifically, using the concept of the Official and Pedagogic Recontextualizing Fields (ORF, PRF), we see here an example of high autonomy in the PRF, which, when coupled with a pro-environmental stance in the ORF as exemplified in the curriculum document, provides an optimum context for the transmission of pro-environmental values and dispositions. Indeed, her class exhibited many aspects of competence model of knowledge recontextualizing (Bernstein, 2000, Chapter 3). As she reports, she interprets the new curriculum as affording her the ability to spend more time with environmental issues:

> What has changed is that what I've done in the past is now validated by it. And now I actually spend more time on it [environmental education]. Where I would have just talked about it a little bit, it wouldn't have been necessarily the focus of a lesson. Whereas now I find that it's much more of a focus. For example, the activity that I did with the newspaper article, the focus was on humanity's impact on the particular environment, habitat, ecosystem. Whereas in the past we might have looked at that, but not in so much detail with regards to the environment [...] For me, I've been putting more emphasis on it [environmental education].

However, given the specific expectations of the curriculum document, the question arises as to the amount of scientific knowledge that students are likely to acquire from these STSE expectations. As shown in earlier chapters, these STSE curriculum expectations are largely disconnected from the scientific content, and may not constitute paradigmatic cases for the effective acquisition of scientific content. In such a case, emphasis on environmental education outcomes may come at the expense of developing powerful scientific knowledges. Because such environmental lessons tended to utilize weakly classified discourses and practices, development of strong scientific identities may not be prioritized—students do not get to practice 'being a scientist' by engaging with the typical practices and discourses of science. For second language learners, having to decode a literacy task before/while getting to the scientific content may pose additional challenges for knowledge acquisition. While story-telling using fictive narratives provide excellent means for developing literacy ob-

jectives, and the strong moral component of these stories encourage the introjection of valued ethical dispositions, utilizing other material could have afforded the classroom a different character. If certain documentaries had been the context setting device in the classroom, it is likely that the discussions may concern themselves with different issues.

Here, there is a need to distinguish between documentaries like Sir David Attenborough's recent BBC productions, where the emphasis is on the wonder and curiousness of the natural world, and others whose main purpose is to arouse feelings of guilt and panic by documenting incidences of tragedy, malfeasance, and ignorance. The essential puzzle here is the character of an appropriate relationship with nature; Michael Bonnett (2006; 2007) argues that we should value nature for itself, and a primary concern should be to *"let things be* (as they are in themselves)—to safeguard, to preserve, to conserve"* (2006, p. 275, emphasis added). Common approaches to environmental education as portraying nature as a lush, blue-skied, maternal, Edenic paradise continually being despoiled (raped?!) by terrifying, filthy, mechanical, masculine forces of 'science' and 'technology' are probably unhelpful in this regard. In what sense, Bonnett argues, can we mean to love nature, especially since nature has no capability of loving us back, and instead will at some time "destroy us either locally, as with hurricane Katrina, or eventually globally, as when the Sun desiccates planet Earth or some chance asteroid strikes?" If we love our pets and other 'cute' creatures, but hate cockroaches and the HIV virus, surely this differential valuing reveals more about our underlying instrumentalism and anthropocentrism than the mask of eco-centrism that it hides behind?

For example, in Alice's reading of *Why should I protect Nature?* students certainly were transfixed by the simple and direct message that appealed to their monochromatic sense of right and wrong, of harm to helpless characters (this time, a generalized 'nature'):

T: [...] trees would have no leaves left, and they would not grow properly. Birds couldn't nest in their branches, and guess what would happen if we all picked flowers and swatted bees? There would be no flowers left, and we would have no honey for breakfast, and what would happen if we drop litter wherever we liked?

Student 1: ugh

T: The countryside would be knee deep in paper, plastic and tin cans, birds and other animals could choke or get trapped in litter, or die.

Student 2: GASP

T: So that's an example of how humans can affect nature and these habitats. No trees, no flowers, no honey, no animals, that would be terrible. So how can we help nature instead? Instead of picking flowers, we can plant flowers in the garden [...]

While this story appears as a fairly innocuous means of telling students about the harms that human behaviour can do on the environment, and these emotional responses are a sign that the message is likely to be retained by students; we see through Bonnett's lens that these approaches are potentially leaving out half the story in that there is little investigation into the underlying differential valuing of certain classes of creatures over others. To the point, while these dispositions towards the protection of a romanticized nature are not undesirable, these approaches ultimately leave students stranded with good intentions, but with little knowledge of how to begin to 'protect nature' in a very real sense. For example, in teaching students about edenic nature as a romanticized ideal, students may also be acquiring aspirations to life in suburban environments, perhaps one of the most ecologically destructive means of living (Greene, 2004). More perniciously, such dispositions leave students vulnerable to persuasion appealing to the public's ecological orientations, as when manufacturers use deceptive labelling practices to essentially 'greenwash' products, and students have insufficient knowledge to judge the veracity of such claims.

In contrast, a scientific approach informs students about reality, through the learning, and ideally, interrogation of justifiably true facts, the process through which students are more likely to gain the skills to critically evaluate evidentiary claims. For these students, learning about taxonomical classification, an expectation deleted from the curriculum document, becomes essential not only because the knowledge value of taxonomy is a vital first step to understanding variation in life forms, evolutionary selection, and the underlying genetic mechanisms. Knowledge of variation may help students understand the rationale for preservation of species diversity, which directly influences the strength of ecosystems to recover from threats to its viability; an infinitely more rational warrant than simply because cute creatures or postcard vistas will disappear if we continue our ecocidal practices.

## 7.     Why so critical?

To round off this section, I am at pains to remind the reader of the methodological commitments and intent of detailing the practices in Alice's classroom—while it appears that several descriptions of her practice leave her in less than rosy light, the aim here is not to direct criticism at a particular educator in order to diminish her practice. Rather, as exemplar of a certain category and representative of 'common-sense' perceptions of how curriculum should be translated into particular pedagogical ativities, the critique is directed towards the general 'common-sense' notions that supports, sustains, and legitimizes practices such as Alice's. In this regard, descriptions of her classroom are necessary in order to provide the reader with sufficient depiction of the typicality of these teachers' contexts, so that a certain measure of veracity and verisimilitude may be appreciated for transfer to other approximately equivalent contexts. To prefigure the analyses and discussions in later chapters, and as a means to guide subsequent reading and interpretation, it is important to

signpost here the character of the upcoming material, so that my intentions here are clear at the outset.

## 8.     Summary

Alice represents the class of experienced and highly competent elementary school teachers who has had a measure of early specialist scientific training prior to their teaching careers[25]. At the same time, her enthusiasm and eagerness to improve her practice has seen her undertake research-based professional learning opportunities, in addition to her own action research efforts and participation at the local science teachers' association. She asserts that her practice is probably leading edge, a result of long term efforts, and that other teachers are unlikely to use similar methods as she does. In other words, Alice is probably close to what may be the best-case scenario for mainstream teachers—well informed, progressive, and willing to try innovative pedagogical techniques. In terms of semantic range, Alice's pedagogical methods show a significant amount of semantic 'waving' and movement through the semantic range, introducing ideas, applying them, and then summarizing them again. Alice also demonstrated excellent pedagogical technique in her ability to choose appropriate issues for discussion, and then discern aspects of the issue to address the various specific expectations of the unit. In this manner, there was very little by way of a discernible boundary between the STSE knowledge expectations and the other expectations in the unit.

However, as her case demonstrates, a major issue for STSE/environmental education at the early grades is the nature of acceptable action for young children—especially since, in the first place, students are not generally aware of the nature and scale of the social/environmental challenges. In

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25.   as opposed to a large number of teachers who enter the teaching profession, especially for elementary teaching, with a general or non-science degree.

informing students of the social/environmental challenge, there exists the tendency to emphasize the aspects of "tragedy, malfeasance, and ignorance" (Gruenewald, 2003); which may be effective in the short term, but in the long run prove to highlight the hypocrisy of adults when they find out that little is done to remedy these issues. While the interaction of an ORF steeped in pro-environmental education ideology and a PRF with high degrees of autonomy appear to be ideal candidates for the transmission of pro-environmental messages, these messages have contradictory effects, especially as the curriculum documents specifies knowledge expectations with a strong ideological character often disconnected from the scientific content of the unit.

# Chapter 7
# Competence models and knowledge

## 1.      Introduction

In this chapter, I describe the contextual factors, and the curriculum and pedagogical decisions taken by Bob. As the title implies, this chapter is an investigation into the possible costs of the pedagogical principle of 'engagement' that appears to be a major concern for educators. Here, there is no attempt to downplay the principle of obtaining high levels of student engagement in the material of the classroom, as it remains an eminently reasonable expectation. However, the theoretical analysis here is with attempts to increase student classroom engagement via an appeal to increasing relevance, by lowering the semantic range of lessons, dealing with concepts in ways that have immediate physical relation to empirical phenomena, and increasing the degree of physical manipulation for students. As I will show, while these activities are reasonable steps to take, they only tell half the story, and potentially do learners a disservice by leaving them low in the semantic range.

## 2.      Competence models—Technicalizing pedagogical practice

In analyzing teacher practices in this study, a challenge arose in attempting to charcterize pedagogical practice in a way that best encapsulated the observed behaviours in relation to their theoretical bases upon which this study is situated. In this regard, an optimum solution was found in the theoretical categorizations developed by Basil Bernstein (2000) to describe (two main) different modes of knowledge recontextualization at the level of the pedagogic recontextualizing field (PRF), the performance and competence models:

Performance modes focus upon something that the acquirer does not possess, upon an absence, and as a consequence place the emphasis upon the text to be acquired and so upon the transmitter. Performance modes select from the field of the production of discourse theories of learning of a behaviourist type which are atomistic in their emphasis [...] From the point of view of competence positions, performance modes were based on the concept of deficit, whereas competence modes were considered to be based on the concept of empowerment [...] the liberal-progressive mode was the basis of cognitive empowerment, the populist mode was the basis of cultural empowerment, and the radical mode the basis for political empowerment (p. 57).

Bernstein also offers means to distinguish between the two models of pedagogic recontextualizing, as shown in the table below:

| Categories: | Competence models | Performance models |
|---|---|---|
| Space/Time/Discourse | weakly classified | strongly classified |
| Evaluation orientation | presences | absences |
| Control | implicit | explicit |
| Pedagogic text | acquirer | performance |
| Autonomy | high | low/high |
| Economy | high cost | low cost |

Table 7.1: Forms of knowledge recontextualizing. From Bernstein (2000), p. 45

To elaborate, the competence model is usually associated with progressive/liberal educative principles, where classification, or boundary maintenance, for space/time/discourse is relatively weaker—in other words, in comptence model classrooms, there is little distinction in the spaces required for pedagogy, lessons may be conducted anywhere, and not, for example, in specifically outfitted laboratories. Weaker classification of time and discourse may also be recognized by, for example as we have seen in Alice's classroom, difficulty in categorizing her discourse and activity sequences into distinct 'knowledge segments', or high integration between different learning expectations.

Evaluation is based on the presence of desirable outcomes, as when a teacher praises artwork for possessing certain characteristics and ignores its shortcomings. Classroom control is implicit, in that students will appear to have a greater decision making power. The pedagogic text is the acquirer itself; i.e. the teacher makes a professional 'reading', informed through her understanding of the social and psychological sciences, of the acquirer's competence development. Competence models require of teachers to be afforded high degrees of autonomy, and present high costs to the state and other institutions in terms of training and maintenance (e.g. low student ratios or else teachers may not be able to accomplish these tasks effectively).

In contrast, for performance models, space/time/discourse are more strongly classified—consider, for instance, an high school laboratory based science class, which we will meet in the next chapter in Clara's case—with performance models, boundaries are strongly maintained, and it is clear when a class is ongoing or not. Evaluation orientation is centred on perceived absences, as when teachers grade student work on how well it matches an idealized norm. Classroom control is explicit, the pedagogic text that is 'read' is the student performance; the autonomy of teachers in performance models can either be high or low, and the cost of preparing teachers for taking up roles in performance model of pedagogy is relatively lower. Along with the potential for higher student ratios, the net result is that performance models are relatively lower cost.

In considering the changes made to the science and technology curriculum, it is plausible to suppose that the STSE knowledge expectations would be better transmitted through a competence model type of pedagogy. In this chapter, we study the case of Bob, who displays attributes of the competence model, and consider the effects on scientific knowledge associated with such an approach.

### 3.    Bob—Grade 7 Science and Mathematics teacher

Bob was a very experienced teacher, and had a good reputation within the school board, due in part to his active participation in the local science teachers association. He had twenty years in teaching and considered himself a fairly successful teacher. Interestingly, his father was also a teacher of sorts, a professor in engineering, and a migrant into the country when Bob was in elementary school. However, Bob did not have an excellent track record with schooling, having dropped out of school twice, but eventually 'seeing the light' and completing his studies, doing well enough to have refereed publications in journals even before graduating from university. He was uninspired by the overly bookish learning that characterized his school experiences, preferring instead hands-on activities. Unsurprisingly, he used to teach design and technology before now taking on the mantle of science and mathematics. He still retains a somewhat disdainful attitude toward overly theoretical perspectives, having on occasion spoken out to me about how he felt advanced physics was so far removed from our daily lives to have no meaningful connection and practical application. His concern for his students fell more on the side of arousing in them their desire to learn, and leaving them empowered to teach themselves, rather than a concern that they learn from an authoritative teacher. Bob interprets environmental education to have meaning over different scales, and holds equally valid approaches that teach about global climate change, and personal responses to environmental issues. Bob's school was in a middle class neighbourhood. Bob made the observation that there were many students whose parents were professionals, some of whom were professors at a university. He was of the opinion that many of the students were doing well and did not need much support from him; instead, he often paid attention to the ones who were falling behind.

Although Bob taught mathematics and science, which provided numerous avenues for integrating the two, a scheduling conflict in the school meant that he did not teach the same classes for both subjects, thus presenting a missed opportunity. Perhaps due to his seniority, he was able to operate with ease and confidence in the school, eschewing some of the more restrictive practices for his own. For example, he often complained about how deficient and ineffective the school computers were (and their choice of operating system, Windows). Instead, he had his own Apple portable computer, and was fond of occasionally proudly announcing that his Apple computer could do things that Windows could not. As the school representative for the local teachers' union, he had on occasion spoken to his colleagues at lunch to stand firm on a political issue affecting staff employment, although a couple of colleagues had disagreed with him then. Despite his desire to influence colleagues, he did not take up any official leadership position, in part because he disliked having to do "administrative paper pushing" and an increased distance between leadership positions and the classroom where he felt could make a greater direst impact. Bob has his own lab and shared a prep room with one colleague; he had a lot of room for his own materials, and in a corner of the lab, he had set up a computer with many of his own curio items, including a decoy pigeon, lava lamp, 'slinky' helical spring, woodwork toys, and a clock with an exposed gear mechanism. Quite often, when setting a task for the students to engage in, bored or distracted (or both) students would walk to this corner, pick up a toy, and start playing with it. The furniture in his lab was the typical bench surrounded by eight stools, which were uncomfortable to sit in for long periods of time.

Bob's typical teaching style in science was to set students up for a task, often involving some form of manual manipulation, usually in groups or pairs, and then circulate to check on individual

students while the rest worked or decayed into chaos, at which point, he would get the class' attention again, remind them of the task, and then continue to circulate. Interestingly, this is in stark contrast to his mathematics periods, where there was a lot more of him fronting the classroom in lecture style presentation of the material. Bob taught the STSE expectations of the unit on thermal transfer. For this unit, he decided to get his students to design and build a mockup of a garment that was ostensibly targeted for use by homeless people. Inspired by a project he discovered over the Internet (http://www.15belowproject.org), he thought to get his students to design, build and test a jacket that could be worn throughout all seasons, could be easily packed away and carried when not needed, and was inexpensive to make. Students were given a set of materials: mylar film, Typar building weather protection sheet, plastic film, duct tape, among a few others, and tasked to research, design and construct a scale model, which was tested by comparing the time it took for a hot water bottle wrapped with the garment to drop a set amount of temperature.

## 4. Teacher perspectives

Bob's goals for science education were in line with his personal philosophy derived from his early life experiences as a learner. He disliked 'book learning', did not agree with knowledge for its own sake, insisting that knowledge had to possess a relevance to the 'real world'.

> I went to a middle school, grades 7 and 8, it was the worst experience in my life, absolutely horrible, there was all book work and nothing but book work [...] and so I dropped out. [...] [In grade 11], I had a physics teacher who was really hands on. [I] Just loved Physics. Just loved it. I had a great year in that respect. Did quite well in all my courses, then the following year I had another paper and pencil physics [teacher] for grade 13 physics, 36%. So I went from 80, 89%, and not having to work too hard for it, to 36% because that guy made us memorize. I don't think he knew his physics anyways, so it was all out of the book. So then I dropped out again. [Bob—transcript B06, line 13]

Separately, in two casual conversations with Bob, he expressed his bewilderment at Bernoulli's theory for explaining airfoil lift, preferring instead what he felt was the more elegant and intuitive explanation derived from Newton's (third) law; and his distrust of the ability of string theory to actually make meaningful explanations of the 'real world'. When asked about the kind of impact he wanted to have when he was a curriculum consultant at the local school board, he replied that he wanted:

> teachers to realize that the textbooks isn't the be-all and the end-all, there's so much more to teaching than the knowledge component that I think it's important for kids to have experience to help kids to see the real things in life. A lot of the stuff we teach is so bloody abstract and so out there that it's irrelevant that they forget it anyways because it doesn't have [.] It's just a bunch of knowledge, and if it's just a bunch of knowledge then I think you're wasting your time. On the other hand, experiences alone are not good enough either, they need to be tied down to things. So particle theory, I'm pushing it, because it's a good theory, it helps kids to tag themselves on to something. But experiences at this level are so critical, because they haven't had the experiences because their teachers are too scared of good experiential science and technology. (B10, L13)

Similar to Alice, knowledge was of a lower priority than dispositions toward learning in general, and, in Bob's case, a general physical 'feel' for phenomena loosely tied to theories of high explanatory utility as the above quote about kinetic theory demonstrates.

On one occasion, I had suggested to Bob the social realist perspective exemplified by Michael Young's powerful knowledge. While he found some reason to agree on the general idea that there existed knowledge worth learning, the specifics of such a philosophy in the classroom elicited a rather strong reaction from him:

> Rigour—part of the problem when I look at my science classes is that, what's the maximum number of kids that I can get turned on to science, that would serve society, and the world, well, by being there? So, you want to keep it interesting enough so that it doesn't become dreadfully dreary, some science the rigour just makes it so dreadfully dreary that people just say, you know what, that's just not where I'm at. [...] I don't

want to kill them with rigour because, then the balance isn't there. I want to keep them interested, and push them from time to time, so the kids like the Kumars and the Kevin Yangs and the Karens [high achieving students], those kids appreciate that there is rigour there, but we also try to keep the Daniel Chungs in line so that they don't distract from others' learning. That's a hard part to play.

For him, intellectual rigour connoted stultifying experiences which would not appeal to his students, and also to test taking as the means to measure rigour:

at the end of the day, the test questions I like to give kids, the what ifs? Those are not being asked, those they don't like to do, because *tests are about knowledge*. They are about facts, and about memorizing, and you know what, they say they studied their ass off last night, I memorized it, and I'm going to forget as soon as I've written that test. And that's what I'm not interested in, I'm not serving my students well, yet at the same time we have to have an element in there, because we have to generate report cards, and how else do you generate marks for report cards that are quantifiable? Give kids tests they'll fit on the bell curve. (emphasis added)

Again, a similar sentiment to Alice's when she remarked that she was not interested in knowledge that would be forgotten quickly after the lessons. Instead, the model of science Bob held up was exemplified by the made-for-television series *Mythbusters*[26]:

I love that show, because they say "we really don't know, let's give it a try". That is to me, pure unadulterated science. You know, you got a problem, you got a question, hey, let's give it a try. We have the equipment, under these circumstances, is it reasonable or not? And that's what I work really hard about, getting kids, 4-5 times a year to do that, appropriate hypothesis, that scientific method, rigour, that kind of thing.

For his students, his primary emphasis was on students who were not performing up to their capacity; the high achieving students are usually capable of taking care of themselves:

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26.   for readers who have no prior exposure to the program, *Mythbusters* follows a formulaic recipe of considering an everyday myth or rarely demonstrated but well known fact (e.g., that a domestic water heater with a faulty pressure relief valve could launch out of a building like a rocket, or that a bullet fired horizontally from a gun and another dropped from the same height will hit the ground at the same time), then analyzing it to isolate variables, followed by building test equipment to verify the myth. Tests are then run with the built equipment, often associated with frequent explosive shenanigans. As of writing, *Mythbusters* were most recently in the news for launching a (fortunately inert) cannonball out of a demolition range and through a private residence.

> In all honesty, most of the kids who are 80%+, the high end kids, will do just fine without the teaching that I'm doing. They're quite capable of going there. But I do think about them, and I do try to address it, but it's usually embedded this way, or it may be some other way. That you're always playing with, but I tend to worry about the lower end kids, because we need to have more successes for the lower ends, because if they don't get those successes, then they're always going to be falling behind..

Bob demonstrated his concern for the weaker learners of the class in several ways: his favoured pedagogical strategy during the time when I was observing his class constituted of distributing tasks to his students; he would then circulate around the classroom to give extra attention to the students who were progressing at the slowest rate. Again, similar to Alice, Bob emphasized his ability to think and act differently from colleagues as a source of pride and a reason for his students' success:

> I do know that when I can get light bulbs going off in kids heads, and they become more independent, then I've done a pretty good job, and I've done it because I haven't just stuck to the script, and because I've taken chances and gone down different routes to try to do different things differently.

Along these lines of thinking differently, Bob also held an unconventional view of environmental education. While he started off with the commonplace perception of 'the environment' as consisting solely of the natural environment "green grass, trees, that kind of stuff", he broadened his conception of the environment to have different meanings at different scales:

> Now, that changed, because, I started to recognize that we have a designed environment as well, this is an environment, just as my stomach and my bloodstream, those are all environments, but they are different scales [...] I want to be as open as possible when we talk about the environment [...] like Einstein did—it was space-time, as compared to Newtonian way of looking at things, you got to recast the perspective; environment is not just the air we breathe, it's not just the trees that are out there.

However, when asked what implications this perspective held for his teaching, Bob responded:

> That we can look at different scales, and that kids can have impact, they may not be able to have impact globally yet, but they can have an impact locally, or even within

their own families, their environment of their home, or the environment of their communities, those are all viable environments for them to have impact in. So I can have impact on the school, by doing certain things [...] The environment being my classroom, my cupboards are clean, and not left dirty, that we have a corner over there, where the microscopes are, and the kids can help themselves. The bright ones will do that. That's really what it is—to not be bound, and to try to keep an open mind as much as possible, even though we are in the control freak business.

In summary, the aspects of Bob's perspectives on curriculum and pedagogy pertinent to the building of this case are his strong belief in the primacy of physical 'experience' as a superior means of acquiring and retaining knowledge, and his general dim view of the significance of abstract knowledge, especially of the kinds more distantly removed from a direct application in a physical context. In the following, I will report on the interplay between these perspectives and the curriculum affordances and limitations as they are demonstrated in Bob's classroom.

## 5.     Curriculum overview

Bob's unit on heat in the environment represents a unit that has undergone significant change through the recent curriculum revision. In the first place, the unit title has been changed to reflect its emphasis—from simply "Heat" to "Heat in the environment". Along with this change is an associated set of modifications to the specific expectations to reduce the 'difficulty' of the unit, make the expectations more 'relevant', and strengthen the semantic density of the knowledge expectations. Compared side-by-side, the changes to the specific expectations are as follows:

| Older curriculum (1998) | Revised curriculum (2007) | Comments |
| --- | --- | --- |
| distinguish between the concept of temperature and the concept of heat (e.g. temperature is a measure of the average kinetic energy of the molecules in a substance; heat is thermal energy that is transferred from one substance to another; SG–, SD+ | expectation deleted in revised curriculum | word search for 'kinetic energy' in the revised curriculum turns out no result related to heat and temperature.<br><br>This is a vital concept in understanding the kinetic theory of molecular motion |

| | | |
|---|---|---|
| explain how heat is transmitted by conduction, convection, and radiation in solids, liquids, and gases; SG–, SD+ | expectation expanded to three independent expectations, and suffixed with "and describe natural processes that are affected by conduction/ convection". | |
| describe how various surfaces absorb radiant heat | explain how heat is transmitted through radiation, and describe the effects of radiation from the sun on different kinds of surfaces (e.g. an ice-covered lake, a forest, an ocean, an asphalt road). | |
| investigate and identify factors affecting the rate of temperature change (e.g. mass, nature of liquid) using a constant heat source; SG–, SD+ | expectation deleted in revised curriculum | Concept of specific heat capacity missing. |
| describe the effect of heat on the motion of particles and explain how changes of state occur (e.g., from a liquid into a gas or vapour); SG–, SD+ | expectation deleted in revised curriculum | Concept of phase change, and explanation via kinetic theory missing. |
| compare, in qualitative terms, the heat capacity of common materials (e.g., water and aluminum have greater heat capacities than sand and Pyrex); SG+, SD– | expectation deleted in revised curriculum | Student lose the development of a general 'feel' for the relative heat capacities of common materials. Word search for 'heat capacity' finds no results throughout entire elementary curriculum. |
| identify systems that are controlled by sensory inputs and feedbacks (e.g. a thermostat); SG+, SD– | expectation deleted in revised curriculum | Technological application of heat in control devices missing |
| design and build a device that minimizes energy transfer (e.g., an incubator, a Thermos flask); SG+, SD– | expectation repackaged into STSE expectation (seen below) | |
| plan investigations for some of these answers and solutions, identifying variables that need to be held constant to ensure a fair test and identifying criteria for assessing solutions; SG–, SD+ | expectation deleted in revised curriculum | principle of fair test is found as part of general "investigation and communication skills" guidelines, but not reiterated here specifically in the context of heat. |

| | | |
|---|---|---|
| compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, bar graphs, line graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., plot a graph showing the decrease in temperature of various liquids from identical initial temperatures); SG–, SD+ | expectation deleted in revised curriculum | principles may exist in revised curriculum, but in de-emphasized, general forms which do not prescribe specifically forms of data reduction and presentation—e.g., revised expectation reads: "use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes (e.g. using the conventions of science, create a labelled diagram to illustrate convection in a liquid or a gas)" |
| recognize heat as a necessity for the survival of plants and animals; SG+, SD– | expectation deleted in revised curriculum | |
| describe the water cycle as a process of energy transfer involving convection and radiation; SG–, SD+ | expectation deleted in revised curriculum | |
| explain why heat is considered to be the final or end form of energy transformation; SG–, SD+ | expectation deleted in revised curriculum | |
| identify the purpose of the specialized features of various instruments that are used to measure temperature; SG+, SD– | expectation deleted in revised curriculum | |
| expectation not in older curriculum | assess the social and environmental benefits of technologies that reduce heat loss or transfer (e.g., insulated clothing, building insulation, green roofs, energy-efficient buildings); SG+, SD– | STSE expectation 1 |
| expectation not in older curriculum | assess the environmental and economic impacts of using conventional (e.g., fossil fuel, nuclear) and alternative forms of energy (e.g., geothermal, solar, wind, wave, biofuel); SG+, SD– | STSE expectation 2 |
| expectation not in older curriculum | identify ways in which heat is produced (e.g., burning fossil and renewable fuels, electrical resistance, physical activity) | revised curriculum expectation is of straightforward nature; SG+, SD–; discrete information that does not build up towards a general framework for understanding natural processes. |

| expectation not in older curriculum | identify common sources of greenhouse gases (e.g., carbon dioxide comes from plant and animal respiration and the burning of fossil fuels; methane comes from wetlands, grazing livestock, termites, fossil fuel extraction, and landfills; nitrous oxide comes from soils and nitrogen fertilizers), and describe ways of reducing emissions of these gases | revised expectation marginally related to the scientific understanding of heat, temperature, and heat transfer; SG+, SD–; discrete information that does not build up towards a general framework for understanding natural processes. |
| --- | --- | --- |

Table 7.2: Curriculum comparison, Grade 7. Strand title: Heat/Heat in the environment

Already from comparing the curriculum documents, the unit displays certain shortcomings from the removal of fairly significant scientific knowledge expectations. As with the general pattern observed in the curriculum analysis, the revised curriculum removed expectations higher on the semantic range (i.e., SG–, SD+), replacing them with expectations lower on the semantic range (SG+, SD–). Concepts of the kinetic theory explanations for heat transfer, phase change, and heat capacity; heat decay; specific data analysis and presentation methods are vital concepts in science with high explanatory utility, capable of application in many different fields and branches. On the other hand, the expectations that have been added to the revised curriculum appear to be strongly environmental in nature, specifying exactly the current received wisdom regarding climate change. This omission of some of the most vital explanatory models and theoretical explanations for thermal behaviour appears baffling in the light of the challenge posed by climate change and the necessity for understanding issues with sufficient depth.

## 6.    Semantic profile

Bob's class was observed for a total of twenty periods, each of fifty minute duration. These were all single period lessons, and took place between February 1 to May 5, 2010, a total of four-

teen weeks. Not all periods were observed, as there were periods that were taken up by tests, or cancelled because of a school function, or clashed with the observation of either Alice's or Clara's class. Also, one of these weeks was the Mid-winter vacation, I was away for a conference for about a week, and Bob and his students went away to an Outdoor Education Centre for a week. Overall, these twenty observation represent a fair sampling of the pedagogical activity in Bob's class. This unit was developed over three major segments, which will be detailed below. Here a quick summary is presented as follows: the first segment, lasting about 5 observations, was concerned with the basic scientific content of the unit; there was the typical teacher directed activities of lecture, Initiate-Recall-Evalute (IRE) discussions, and a 'standard' laboratory investigation. In the second segment Bob used different scenarios of park fires to develop the concept of the effects of heat in the environment, while the last segment Bob got his students to engage in a design challenge, building a model of a jacket for homeless people.

*7.6.1      Basic scientific content*

When I started observing Bob's class, they had already gone through some basic teaching around the concepts of thermal transfer via conduction, convection and radiation, and were starting on a laboratory investigation. Using what Bob termed a "Conduct-o-meter", essentially five metallic rods of dissimilar materials stuck into a central hub (see Figure 1, p. 215). Applying heat from a bunsen burner to the hub, heat energy travelled through conduction outwards along the spokes, at the end of which were tiny notches into which some solid wax was applied. The rate of heat transfer was implied by the time it took between the application of heat and the melting of the wax in the notches. The students were then supposed to work on calculating the rate of con-

duction, and to prepare a graphical representation of the rates of conduction for the different metals.
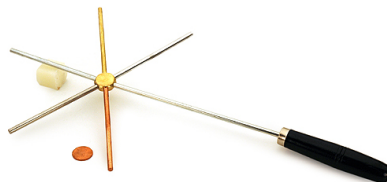


Figure 7.1: Conduct-o-meter. A US 1-cent coin is shown alongside for scale

| Lesson/ Phase | Description | Coding/Comments |
|---|---|---|
| Lesson 1 | | |
| Phase 1 | Instructions: Bob brief the class as to the expectations for the practical session, some safety precautions, and some general points of order | SG+/SD–/ESR: Low. Instructions are context specific, and do not use semantically dense terms to convey specific instructions. Semantic range remains low level as this phase is primarily concerned with the specifics of getting the practical done. |
| Phase 2 | Practical session: Students work with conduct-o-meter as Bob circulates the class, resolving issues with practical investigation, answering questions, asserting classroom behavioural norms, and posing questions to students. | SG+/SD–/ESR: Increasing. Students working within the context of the practical investigation, generally using everyday speech to describe observations. Semantic range is increasing as students are noticing trends and making generalizing comments. |
| Lesson 2 | | |
| Phase 1 | Instructions: Bob briefs the class the order of activities for the day's lesson—they are to continue working on the laboratory assignment as he circulates to check work. | SG+/SD–/ESR: Low: General instructions, points of attention for class mostly relevant to classroom behavioural expectations, and worksheet instructions. |

| Phase 2 | Individual seatwork: student work period. | SG−/SD+/ESR: Increasing. Students work on calculations and graphical representation, Bob circulates and quizzes students on their understanding of thermal radiation concepts with reference to physical phenomena experienced by the class in common. |
|---|---|---|

### Lesson 3

| Phase 1 | Instructions: Bob briefs the class the order of activities for the day's lesson—they are to continue working on the laboratory assignment as he circulates to check work. | SG+/SD−/ESR: Low: General instructions, points of attention for class mostly relevant to classroom behavioural expectations, and worksheet instructions. |
|---|---|---|
| Phase 2 | Individual seatwork: student work period.<br><br>(essentially, lesson 3 is a repeat/continuation of lesson 2) | SG−/SD+/ESR: Increasing. Students work on calculations and graphical representation, Bob circulates and quizzes students on their understanding of thermal radiation concepts with reference to physical phenomena experienced by the class in common. |

### Lesson 4

| Phase 1 | Instructions and classroom administration: attendance taking | SG+/SD−/ESR: Low: General instructions, points of attention for class mostly relevant to classroom behavioural expectations, and worksheet instructions. |
|---|---|---|
| Phase 2 | IRE discussion: Discussion on the mechanisms of thermal transfer; properties of good/poor conductors of heat based on everyday life examples, e.g. metal cooking utensils need an insulative handle otherwise they will be too hot to handle; molten glass rods can be held very close to the melted segment because glass is a poor conductor. | SG+/SD−/ESR: Increasing: Bob makes use of specific empirical phenomena to develop, via an inductive approach, the generalizing principles of material selection based on thermal properties, and also of thermal transfer. |
| Phase 3 | Individual seatwork: Class resumes work on completing the laboratory report. | SG−/SD+/ESR: Increasing: Students working to reduce empirical data, making calculations and fitting information into the condensed form of bar graphs |

### Lesson 5

| Phase 1 | Individual seatwork/pair/group discussion: study time for quiz: Bob allows students time to review material prior to the quiz in the next phase. He circulates to assist students, paying attention to the weaker students in class. | SG−/SD+/ESR: High: In preparation for the test, discourse was focussed on conceptual understanding of scientific principles |
|---|---|---|

| | | |
|---|---|---|
| Phase 2 | IRE discussion: going through laboratory report: Bob returns corrected work, and discusses where students typically made mistakes, and the portions where attention was needed. Students making corrections as needed. | SG–/SD+/ESR: Increasing: Bob talks in general terms about the empirical phenomena encountered during the laboratory investigation, and discusses the properties of an ideal laboratory report by reference to reports submitted and corrected. |
| Phase 3 | Student individual work: end of activity summary worksheet | SG–/SD+/ESR: Increasing: summative activity to promote generalizing principles derived from the activities and discussion to date. |
| Phase 4 | class 'down time': Bob declares "Ok guess what, we don't have time for the quiz! Take a break for 10 minutes, good luck for your other test" | N/A. |

Table 7.3: Coding summary for Bob's classes, Segment 1: Scientific content

Through this series of lessons, Bob's pedagogy can be seen to follow a wave-like trajectory when examined for its semantic range. Unfortunately, no observation was made of Bob's lessons prior to the first laboratory session, but as we will see for the next segment, these missing observations are likely to consist of direct teaching via lectures and/or IRE discussions introducing the concept of thermal transfer. In any case, what is clear is that the practical investigations ground the abstract concepts of thermal transfer in realistic empirical phenomena, and especially for students at that age, provoked a somewhat visceral response as the bunsen burners hissed and produced hot flames. Certainly, for the student who got (mildly) burnt, she acquired knowledge of heat of a variety that had very strong semantic gravity! Crucially, a series of activities towards the end of the session helped to relate the empirical phenomena towards the building of generalizing principles that constituted the learning, the 'take home' messages that Bob emphasized.

### 7.6.2    *Park fires to develop concept of heat in the environment*

In this segment of his teaching for the unit, Bob planned an activity designed by Parks Canada. This activity had students reconsider the notion that fires produced uniformly negative

consequences for ecosystems, with a more contemporary perspective that fires had different consequences for different local environments. Along with this message was the justification for leaving some fires alone or even deliberately starting fires so that there would not be an over-accumulation of combustible wood. Taught over four parts spanning three weeks, the first part was a lecture-video presentation and IRE session where Bob introduced the concept of park fires with reference to historical broadcasts of the Canadian Broadcasting Corporation. In the second part, students were assigned group tasks—to consider hypothetical scenarios concerning park fires in different cases. For the third part, students presented their work to the rest of the class. Finally. students were assigned to research and produce an informational pamphlet ostensibly for visitors to national parks to describe fire management policy.

| Lesson/ Phase | Description | Coding/Comments |
|---|---|---|
| | Lesson 1 | |
| Phase 1 | Test taking: quiz from previous session is re-scheduled for this period | SG-/SD+/ESR high: In this quiz period, students work on abstract principles of thermal transfer, based on hypothetical scenarios only sufficiently related to empirical contexts that question comprehension is not impeded. |
| Phase 2 | Lecture/IRE: Bob introduces the concept of fires in natural settings and especially National Park properties | SG+/SD-/ESR: Decreasing: Bob uses plain language to discuss fires, and introduces several cases to illustrate theoretical range of possibilities |
| Phase 3 | Video presentation/IRE: Bob shows the videos to the class, along with a running commentary and strategic pauses to discuss issues that arise. | SG+/SD-/ESR: Decreasing: Content of discussion is strongly context dependent (even though based on a context that is not immediate in chronological order), and Bob makes the effort to point out how the video presentation illustrates aspects of theoretical considerations. |
| | Lesson 2 | |

| Phase 1 | IRE discussion (last 7 minutes of the session)—I arrive late because of transit delays. | SG+/SD−/ESR: Decreasing: Continuation of discussion from lesson 1 |
|---|---|---|

<div align="center">Lesson 3</div>

| Phase 1 | Instructions: Bob issues instructions to students as to the order of activities for the day, and the expectations for the task assigned. | SG+/SD−/ESR: low: Bob tells the students via lecture, about the activity and its expectations. No/little abstract/technical language is used, and ideas are not being developed toward generalizing principles nor providing instances of high-level concepts |
|---|---|---|
| Phase 2 | Group work: Students work in large groups (10, 10, 7— see section 6.2) to develop action plans for three different scenarios of fires in park properties. | SG+/SD−/ESR: decreasing: Students making use of general heuristic principles to make decisions in specific case scenarios. |
| Phase 3 | Presentations: A group representative relates the findings for each group. 'Presentations' are 3-4 sentence long reading from prepared texts. | SG+/SD−/ESR: decreasing: Students share with the class their decision making logic, an application of the heuristic principles introduced by Bob in earlier lessons, in specific case scenarios. |
| Phase 4 | Individual seat work: Students write up the conclusions of their discussion as individual work. Questions on worksheet are largely identical to questions required for presentation. | SG+/SD−/ESR: decreasing: Students are essentially writing down responses to questions similar to that discussed in earlier phases. |

<div align="center">Lesson 4</div>

| Phase 1 | Instructions: Bob issues instructions for the order of the day's activities | SG+/SD−/ESR: low: classroom administration, direct instruction, no development of higher semantic range concepts. |
|---|---|---|
| Phase 2 | Individual Seatwork: Continuation of activity from last lesson, while Bob circulates. Many students are already complete, but Bob is giving attention to make sure weaker students can obtain passing marks for his course. | SG+/SD−/ESR: decreasing: Students are essentially writing down responses to questions similar to that discussed in earlier phases. |
| Phase 3 | Lecture/IRE discussion: Bob talks about next task: creating a pamphlet for distribution to park guests. | SG+/SD−/ESR: increasing: summarizing the main points of previous lessons and drawing out important aspects of lessons, suggesting to them what should be in the pamphlet. |
| Phase 4 | Group work: Brainstorming ideas for pamphlet | SG+/SD−/ESR: increasing/decreasing: students plan from general principles, and extract features of exemplars, what an ideal pamphlet looks like, and then move on to what their specific design for a pamphlet will become. |

| | Lesson 5 | |
|---|---|---|
| Phase 1 | Library research and individual work period: Students research online resources (e.g. Parks Canada website) for information pertaining to the situation of wildfires, and to find pictures for inclusion into their pamphlet. This whole period is dedicated to this activity while Bob circulates and provides extra attention to students who need it most. | SG+/SD–/ESR: decreasing: students work to realize their pamphlet, starting from abstract, planned notions towards their productions 'on screen'. |
| | Lesson 6 | |
| Phase 1 | Continuation of individual work at the computer, from above | SG+/SD–/ESR: decreasing: students work to realize their pamphlet, starting from abstract, planned notions towards their productions 'on screen'. |

Table 7.4: Coding summary for Bob's classes, Segment 2: Park fires

Overall for this segment of his unit development, the semantic range of his pedagogy undergoes a decidedly reduced amount of movement. Considering the segment of lessons from a synoptic view, the segment begins with an abstract discussion of woodland fires, followed closely by video presentations, which develop the main learning point of the segment—that the fires are not universally negative occurrences that need to be put out the instant they are discovered. So far, the activity has been high on the semantic range, and while the group activity poses scenarios for students to apply this newly acquired knowledge, thus cementing the concept, the semantic range for the remaining periods does not recover significantly to match the level of at which the segment opened with. Here, there is an acknowledgement of a shortcoming of the coding instrument, in that while it may give a general sense of where the phase is 'moving', or what the discourse of the phase is doing to meaning in the class, it does not distinguish between different quantitatively comparable extents to which the semantic range may be modified, and how much change is being made to meaning. This will be further discussed in a later chapter. For now, this inadequacy non-

etheless, the point to be made here is that the semantic range for this segment of Bob's lesson appears to develop as illustrated in Figure 2 below.
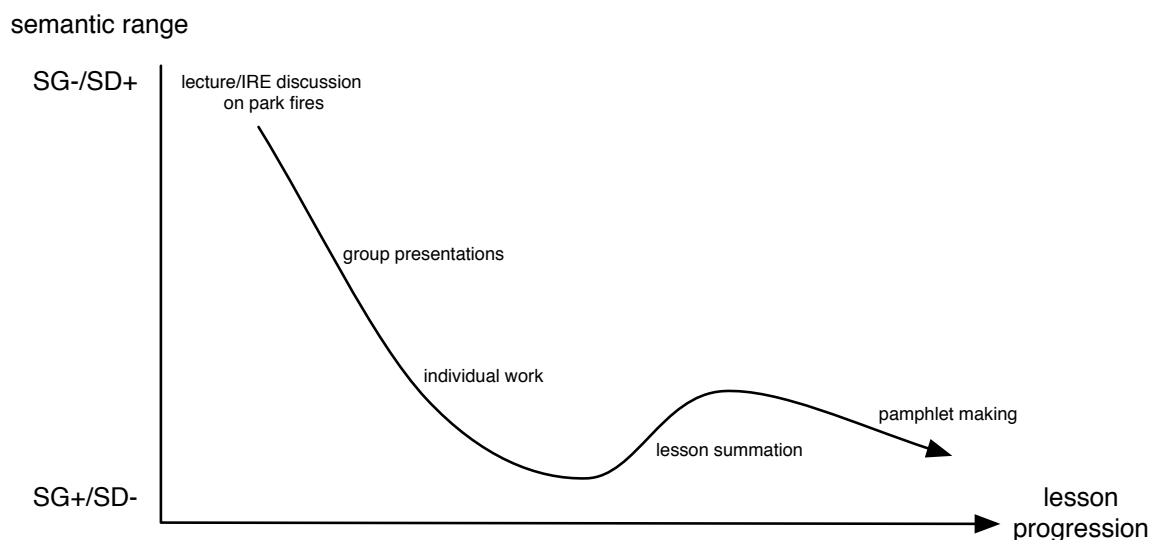


Figure 7.2: Illustration of semantic range for Bob's classes, Segment 2: Park Fires

Here, the significance of this semantic profile lies in the manner in which there is a lack of a cumulative development of knowledge based on the original introduction of the organizational theme for the series of lessons, which was summed up succinctly by Bob—"[Park fires?] it depends". Essentially, this concept was demonstrated, the students produced work to illustrate their understanding, but Bob chose not to further develop the contextual scenarios to develop other ideas. For a fuller discussion, please see section 7.1 below.

### 7.6.3 *Building models of jackets for homeless people*

In the second half of the lesson observation series for Bob, I studied the implementation of series of lessons that would be most suitable for the fulfilment of the STSE specific objective 1.1; specifically, the objective requires that students "assess the social and environmental benefits of technologies that reduce heat loss or transfer (e.g., insulated clothing, building insulation, green

roofs, energy-efficient buildings)". Further to this, the curriculum document suggests a few guiding questions; pertinent to the task planned for students, Bob picked up on and elaborated this suggestion:"(a) Insulated clothing protects our bodies and increases our ability to enjoy outdoor activities in winter. What science and technology concepts are at work in coats designed for use in cold weather? Who might be interested in such designs?" In a manner consistent with his teaching philosophy, he had decided to ground the learning objective in a realistic (or at least, plausible) context to accomplish several learning objectives in the process of one activity. During the planning stages, he revealed that an inspiration for the activity derived from an actual project undertaken by fashion designer Lida Baday, a graduate of Ryerson University in Toronto. Based around a "jacket with pockets" scheme, the normally light garment had a lining layer that could be filled with crushed up newspaper or other similar found insulation when the outdoor temperature was low. With the additional insulation removed, the jacket could serve as a spring or autumn water resistant outer layer, and in summer, the jacket could be folded into itself and carried like a backpack.

Bob planned this segment as a design challenge to his students; after orienting the students to the aims of the project and issuing the instructions for the overall conduct of the challenge, he allowed the students about 2–3 sessions for them to brainstorm, design, and manipulate the materials to get a physical sense of the material properties. Another 3–4 sessions were spent on the students actually crafting the jacket, 1–2 sessions on testing the jacket's properties, and 1–2 sessions were spent by the students doing individual work completing their reports. A more detailed description and coding of the lessons follows:

| Lesson/ Phase | | Description | Coding/Comment |
|---|---|---|---|
| | | **Lesson 1** | |
| 1 | Phase | IRE discussion: Bob introduces the jacket project to the student, a short discussion of homelessness results, Bob issues project requirements. | SG–/SD+/ESR: decreasing: Bob begins from abstract introduction to the project and what it entails, discusses homelessness in theoretical terms, but proceeds to ground ideas and concepts in scenarios more immediately recognizable within realm of students' experiences. |
| 2 | Phase | Brainstorming, initial experimentation: In groups, students discuss initial plans for their project, and start handling materials to get a 'feel' for the materials. | SG+/SD–/ESR: decreasing/increasing: brainstorming activity encourages students to develop from abstract plans to a workable design, while the manipulation of materials encourages students to consider and abstract particular properties relevant to the design. |
| | | **Lesson 2** | |
| 1 | Phase | brainstorming/design session: continuation of phase 2 from lesson 1. Note: students are beginning to spend time off-task | SG+/SD–/ESR: decreasing/increasing: brainstorming activity encourages students to develop from abstract plans to a workable design, while the manipulation of materials encourages students to consider and abstract particular properties relevant to the design. |
| | | **Lesson 3** | |
| 1 | Phase | brainstorming/design session: continuation of phase 2 from lesson 1. Note: students are beginning to spend time off-task | SG+/SD–/ESR: decreasing/increasing: brainstorming activity encourages students to develop from abstract plans to a workable design, while the manipulation of materials encourages students to consider and abstract particular properties relevant to the design. |
| | | **Lesson 4** | |
| 1 | Phase | design/building session: students start working on building the jacket | SG+/SD–/ESR: Low: session is mostly concerned with actually making the jacket. |
| | | **Lesson 5** | |
| 1 | Phase | design/building session: students work on building the jacket | SG+/SD–/ESR: Low: session is mostly concerned with actually making the jacket. |

| | | Lesson 6 | |
|---|---|---|---|
| 1 | Phase | design/building session: students work on building the jacket | SG+/SD–/ESR: Low: session is mostly concerned with actually making the jacket. |

| | | Lesson 7 | |
|---|---|---|---|
| 1 | Phase | design/building session: students work on building the jacket | SG+/SD–/ESR: Low: session is mostly concerned with actually making the jacket. |
| 2 | Phase | Lecture: Bob calls class to order and summarizes the progress of the class so far, reminds the class that they have to continually evaluate their own learning, | SG+/SD–/ESR: Increasing. While mostly talking about the physical limitations and mechanical problems posed by the material manipulation, Bob tries to generalize the situations the students are experiencing and offer advice for all. |
| 3 | Phase | design/building session: students work on building the jacket | SG+/SD–/ESR: Low: session is mostly concerned with actually making the jacket. |

| | | Lesson 8 | |
|---|---|---|---|
| 1 | Phase | Instructions: Bob issues instructions for the order of the day's activities: Students who have completed their models will take turns to test it, while others waiting to test the models will write up their report. | SG+/SD–/ESR: Low: Bob's instructions are administrative. |
| 2 | Phase | Model testing/report writing (concurrent): Boiling water is poured into a water bottle wrapped with the model jacket. A thermometer measures the temperature drop over a set period of time. | Model testing: SG+/SD–/ESR: Increasing: Students obtaining abstract results from their experiment. Report writing: SG–/SD+/ESR: Increasing: Students condense the work done in their investigation session into their written reports. |

| | | Lesson 9 | |
|---|---|---|---|
| 1 | Phase | Continuation of Lesson 8/Phase 2 | Model testing: SG+/SD–/ESR: Increasing: Students obtaining abstract results from their experiment. Report writing: SG–/SD+/ESR: Increasing: Students condense the work done in their investigation session into their written reports. |

| | | Lesson 10 | |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | Phase | Continuation of Lesson 8/Phase 2 | Model testing: SG+/SD–/ESR: Increasing: Students obtaining abstract results from their experiment. <br><br> Report writing: SG–/SD+/ESR: Increasing: Students condense the work done in their investigation session into their written reports. |
| 2 | Phase | Presentations: groups present a summary of their project, highlighting design features, considerations, and limitations. | SG–/SD+/ESR: Increasing: Design elements and specific features of model jacket are abstracted and presented as instances of of design considerations. |

Table 7.5: Coding summary for Bob's classes, Segment 3: Model Jackets

For this segment, a major concern for Bob appeared to be the mechanical aspect of constructing the model jackets, a perspective he confirmed at interviews and discussions. In terms of semantic range, while the project starts reasonably high on the semantic range with a general discussion of homelessness and the general design attributes successful jackets, the semantic range quickly dipped, and spent a long time low on the semantic range as students struggled with the manipulative challenges of constructing their models. Bob deliberately relaxed the pace of the lessons, so that there was a large percentage (at least 20-30%) of off-task behaviour at any one time during the construction phase. Towards the conclusion of the series of lessons, there were attempts to raise the semantic range of the classroom discourse, but as with the Park Fires segment, no significant new knowledge was developed, and the classroom discourse and activities did not increase in semantic range sufficiently.

## 7.    Discussion

Like Alice, Bob possessed a high degree of autonomy in his pedagogical context—he was a senior and trusted member of the school faculty, had previously been a curriculum leader at the

school board, and had ever been approached for consideration to take up an administrative position. More clearly than in Alice's case, Bob's context offers us a look at the consequences of the competence model of recontextualizing (Bernstein, 2000, Chapter 3) for knowledge acquisition.

More obviously than in Alice's case, Bob's pedagogical recontextualizing of the STSE specific expectations was well described by the competence model. Space/Time/Discourses were weakly classified—pedagogic spaces were not well defined; students were free to move about the class, especially during the model jacket building stage; within the period, there were no strictly sequenced or paced activities punctuated by teacher instruction; and the discourse of Bob's class was not strongly distinguished from, say, typical discourses expected in a design and technology class. Bob emphasized to students that the products of their work had to display particular aspects, and he was careful not to point out deficiencies in students' work (e.g., from Table 7.4, very short presentations were acceptable). Classroom control was largely implicit, with Bob considering his students as largely self-regulating learners, letting them move around the class freely to pick up the many artifacts around the laboratory during discussion time. The pedagogic text centred around the production of certain dispositions in the students, and the actual pedagogic performance of the students (making a model) was slightly less important. Students were given a high degree of autonomy, consistent with Bob's perception or preferred treatment of his students as self-regulating learners who could decide for themselves that paying attention to the classroom task was beneficial for them in the long run. Finally, Bob acknowledged that his pedagogy was fairly high cost:

> My grade 8s that I have now, I can give them these kinds of tasks now, they know the routines, they know how that works, they know socialization is allowed while they're doing the hands on. Here it'll take three times as long as it has to, next time, it will take three quarters the time it ought to. You gotta get over the hump. Next year, a lot of the kids will be the same [in Grade 8], guess what, there will be things I don't have to teach again.

In other words, and as may be surmised by his perspectives on education (related earlier) and the kind of science education he aspires to, Bob's pedagogic recontextualizing was well described by the competence model, specifically the liberal/progressive mode. In the following sections, I will discuss some affordances and limitations of the competence model of pedagogic recontextualization, as seen through Bob's lessons on two curriculum segments.

### 7.7.1 *Park fires to develop the concept of heat in the environment*

As may be seen in Table 7.4, these series of lessons took place over about seven periods, totalling about two weeks of term time. As an observer to Bob's classroom and curriculum preparation processes, I had requested access to his curriculum preparation periods, where I often had discussed his plans for the upcoming lessons, and also reviewed prior lessons with him. On one occasion, Bob shared with me his planning considerations and learning objectives for this segment:

> One of them, humans have the power to make decisions, and implement those decisions. That we have a lot of impact on the environment, and that human impact in the past, may not necessarily be indicative of [inaudible]. That extremes of heat can play a role in the continuation and adaptation of life [...] I think here I would just talk about the fact that fire clears away a lot of dead materials, and it allows for the renewal, provides favourable conditions for other kinds of life, because that's really what the point of this is. Heat in the environment, heat and life relationship. If we have too much heat, it kills, if we have to little heat, we die too.

Sensing an opportunity to discuss the carbon cycle, I had asked if that would be one of the learning objectives, or perhaps even something that he might discuss in passing. Bob was reluctant to consider teaching the concept, as well as other opportunities to discuss related ideas such as Geographical Information Systems (GIS) methods, challenges of mapping, weather prediction, among others. As a measure of his perceived and actual autonomy in recontextualizing knowledge, none of his stated learning objectives coincided with the specific expectations in the curriculum docu-

ment for the unit on heat. While an expectation in the Grade 7 *Understanding Life Systems* strand[27] was a decidedly better fit for this activity, Bob did not clarify that he was directing the activity for this strand. Instead, he repeated that this was designed for a unit on heat in the environment, probably because of the very visceral phenomenon of fire in a natural environment.

The group work was assigned to groups of 10, 10 and 7 students, and, consistent with the weak classification of time and discourse characteristic of the competence model, Bob did not assign roles and responsibilities for all the group members (e.g., time-keeper, presenter, note-taker, etc); neither did he insist that the students choose amongst themselves these duties. Eventually, when it was time to present, groups made presentations that were 3, 4, and 4 sentences long, and consisted mainly of reading out parts of the question, before a short sentence stating their position that the fire should/should not be allowed to burn, and why. The level of analysis was straightforward, and while students had access to maps, these maps were not used in any significant way to arrive at the group's decision (e.g. no reference to map scale, rate of fire spread, or anything beyond a rough orientation of the elements of the scenario). Listening in to the discussions within the group, the scenarios appeared to not provide sufficient equivocation to allow discussion and group deliberation on issues. In at least one of the groups, a few individuals within my hearing range had moved on to a more pressing discussion on the use of modification chips to allow handheld consoles to play games they were not designed to.

The major learning of this segment may be better summarized by the video that Bob showed his students, a production of Parks Canada, see Figure 7.3 below. Specifically, the aim of these les-

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27.  the expectation reads: "analyse the costs and benefits of selected strategies for protecting the environment" or "use scientific inquiry/research skills investigate occurrences that affect the balance within a local ecosystem"

sons was to transmit the revised understanding that fires need not be a uniformly negative occurrence that should be extinguished the moment occurrences are detected. In fact, the video shows Park firefighters/rangers, calmly and deliberately walking through the wooded areas, settings fires by spraying some flammable liquid, and in other scenes, portrayed them as alternately smiling or dancing to a soundtrack that might be more appropriate in a downtown club; in other words, enjoying themselves. With a professorial personality pointing to the charred bark of a tree and declaring its health and vitality, the video ends with a scene of lush greenery, with large mammals grazing on the fresh vegetation.

This lessons segment highlights some of the contradictory effects that may arise from certain interpretations of environmental education present throughout the ORF in combination with a PRF aligned to the overarching goals of the ORF, in the sense of adopting a competence model of knowledge recontextualization. While these lessons were an excellent means of transmitting the message that fires in the natural environment can be completely innocuous occurrences to the point that park wardens might deliberately start and spread them, the relation between these lessons and the ostensible scientific content of this unit was rather more tenuous. This weak connection was even detected by the students, when, during one lesson[28] Bob read out an excerpt from *Honour Earth Mother*, a book by an Ojibwa author detailing the Native American perspective of affection and reverence for the land. Several students actually made verbal, expressions of dismay or confusion (e.g. "*huh?*"); and Bob had to actually address the class to explain specifically why the lesson was relevant to science.

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28. which, unfortunately was not recorded due to a faulty equipment setting.

Because of the emphasis of the competence model in transmitting attitudes and dispositions, rather than the acquisition of knowledge and the (re)production of particular texts, the scientific content knowledge of thermal transfer became disconnected from the learning gains of these lessons; for example, no substantive discussion into the mechanisms of conduction, convection and radiation were adopted during these lessons; neither were concepts of thermal conductivity rate, or the kinetic theory model of heat transfer. Even probably the closest expectation to these activities, an introduction to the sources of greenhouse gases in the environment (and possibly related, the concept of carbon cycling), was subordinated to the liberal/progressive competence model of pedagogic recontextualization, in wanting students to develop their own positive attitudes towards science by presenting 'cool' material which Bob believed would engage them in self-directed learning and longer term benefits which would outweigh an overly narrow 'bookish' focus on 'facts'.

What do *you* see here?

Fire has shaped Banff National Park
for over 10,000 years

<fire fighter dancing to music>

Park vegetation has adapted to coexist with fire

Through "death and destruction"
our ecosystem can experience renewal

One month after fire

Figure 7.3: Storyboard for video in Bob's class—Park fires

### 7.7.2        *Building models of jackets for homeless people*

In this segment of his lessons, Bob appeared to be directing his pedagogic recontextualizing mainly towards the implementation of the STSE learning expectation 1.1: "assess the social and environmental benefits of technologies that reduce heat loss or transfer (e.g., insulated clothing, building insulation, green roofs, energy-efficient buildings)", although the scientific principles of thermal transfer were also to be developed through this activity. The entire segment took two and a half weeks, with one week break in between when Bob and his students went to an Outdoor Education Centre for a stay-in visit. As summarized in Table 7.5, a major emphasis of this series of lessons was the design and making of the model. This took a long time, and as many of the students did not have good motor control skills, these students struggled with the requirements of model making. Bob was defensive about this aspect of the lesson implementation; he argued that part of the reason why the class behaved as they did could be traced to the experimental nature of this lesson; while he had run a similar activity before, this was the first time the students were confronted with a design challenge, and so they were still struggling with the standards for appropriate behaviour during such sessions. Still, Bob felt that it was a necessary price to pay to get the students inducted into a scheme of work that was unconventional. When I pointed out during one of the review sessions that I overheard extended conversations in class that was not related to the work, and suggested that the students may have been caught up with the practical implementation issues and material handling, he responded:

> You know what, [...] you're right, they are getting bogged down, and that's ok, they're going to learn it somewhere along the line, and maybe better here than elsewhere. So no, I don't have a huge problem with that, like I said, we can afford the time in one sense, the social aspect of learning is very important too, and if they are finding time to talk about it. You're right, some of the talk is off-task, and that's why I do that kind of thing, that behaviour has to be dealt with [...] Later on when they have another prob-

lem to solve, they'll think back and how did I use that, and what did I learn from that? And that could be really potent later on, especially my shop class, where we do in fact construct models, it does take longer because they are unfamiliar with the techniques, and with the materials, but once they learn it... It's like going from static to dynamic friction, we've got to get over the hump, so to speak, and if this is the hump right now, where they're spending time off task, some time on-task, and reflecting back and forth, about how they did and explaining it to each other, that's ok, because they have to get over the hump at some point, No, they don't have to, may not have to, but now they have the experience, they know how it works, I know how it works with them, and so, next time it allows me to move that much faster. You gotta pay the price along the way, I'm not too worried [...] Is it time necessarily wasted? I don't think so? Is it time best used? No. But you gotta get over the hump.

Again, quotations like this remind us of the 'high cost' (see page 201) nature of the competence model of pedagogic recontextualization—while the development of a positive attitude towards classroom work and familiarity with mechanical manipulation was a decided virtue that should be inculcated in students, in observing Bob's class there were periods of time when it was hard for an untrained eye to discern that these attitudinal goals were being achieved. Bob also recognized that this series of lessons was decidedly atypical of science lessons he engaged in:

Oh no, this is atypical for most classrooms that I've ever been in, that's not to say that it's better, or worse than any other classes, it's just a different way of going at it, I could make them read notes and memorize, I could be way more efficient about getting the curriculum across to them, but the curriculum should be found in reality, not just a bunch of words that are memorized and promptly, forgotten. And I think that's where we get the payback, it's with the manipulation, here, they are getting good concrete [.], and that makes it worthwhile [...] Is it the most effective use of time for learning physics? Yes, because now we have concrete things to talk about instead of being that large group industrial setting, it's becoming much more personal, that's more challenging, it's taking more time.

Here, without prejudice, the case of Bob's pedagogical recontextualization illustrates the fundamental challenge for science education: the goal is not so much as concrete over abstract, or vice versa, but to find an effective means to bridge the two. Again, we are confronted with the utility of

the LCT approach to describing pedagogy—it is not that good pedagogy is exclusively higher (more abstract) or lower ('concrete') on the semantic range, but it is the careful, deliberate movement up and down through the range that is indicative of high quality pedagogy and cumulative development.

Whenever Bob circulated around the classroom, he often quizzed his students on their design choices, and the students had to fill in worksheets to justify their choice of material and design, especially using the scientific concepts of heat transfer taught in prior lessons. However, there was a general sense that development of knowledge was not as important as their classroom participation, creative generation of ideas and mechanical competencies in dealing with the model making. For example, instead of considering a simplified model or even a typical cross-sectional representation of the jacket material, and repeatedly testing for different permutations of layering and/or mechanical configuration (e.g. crumpled/pleated/folded, etc)[29], Bob had the students design and build a life-like model, resulting in a doll-sized garment that was difficult to handle; one group had even decided to stitch material together with needle and thread. When recounting the lesson series, Bob acknowledged that students had difficulties with mechanical manipulation, and agreed that future implementations of this activity should be reduced in its complexity; he also acknowledged that the summative discussion at the end of the class was something he was aiming to do more frequently, but he was often limited by the period length.

Bob had suggested that the project could be a means to get his students thinking about the issue of homelessness; however, this aspect of homelessness was limited to a six-minute long discus-

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29. as just one possibility of a series of activities that would more explicitly demonstrate the thermal transfer properties and introduce the concept of fair testing.

sion that did not delve too deeply into a substantive discussion of the issue. For example, a student

asked how homeless people ended up that way; Bob responded:

> Well, there's lots of reasons, that may be a good question to ask. Could be mental illness, could be they were abused by their parents, could be that they lost their job, they could be gambling addicts. There are lots of reasons why people become homeless, and why they stay homeless, but one of the things we do know is that homeless people die younger, because they get sick, because they can't control their environment very well, and we know that if we can help them see the future and be treated with a little bit of dignity, that gives them some dignity, and they are able to hopefully help themselves a little bit more as well. But they need a helping hand along the way.

Another student had made the comment that "my parents say that people are homeless because it's

their fault, they get fired, they can always get another job, it's their fault". To his credit, Bob was

quick to correct this misunderstanding:

> Yes, some, it is, but who are we to judge that? How do we know for sure unless we stop them and say, why are you homeless? I've talked to homeless people; I used to be a courier downtown, and you ask, how did you end up here? [They tell me:] You know what, my dad beat me up regularly. I couldn't live at home. Well, the downtown streets are a lot safer than being at home for some cases. And yeah, sometimes it's the people's own fault, but more often than not, I bet... But it doesn't matter how they got there. What we can do is help them try to get better.

Overall, although Bob attempted to bring the students away from naïve understandings of homelessness, from the amount of time spent on the issue, and the consequent depth of discussion, it

was clear that a deep understanding of the contributory causes and means to help in effective ways

did not play a significant role in Bob's pedagogy. In other words, the setting here was directed toward the development of a synthetic context whose purpose was to contribute to student engagement, and not the actual resolution of a social issue as would be expected of an action-oriented

pedagogy as advocated by researchers reviewed earlier. This episode demonstrates the challenges

that confront practitioners of an inter-disciplinary pedagogy: a high degree of knowledge in mul-

tiple disciplinary domains needs to be effectively reconextualized and made relevant to the context at hand. In this case of homelessness, a discussion that does not just pay lip service to the concept of ameliorating the homeless situation requires teachers to at least have passing knowledge of sociological understandings of homelessness, and perhaps even the psychology and psychiatry behind mental illnesses that often afflict homeless people. Unless these conditions are met, it is likely that such inter-disciplinary approaches remain facile and superficial.

In summary, certain pedagogic decisions were out of the question because of the liberal/progressive competence mode of pedagogic recontextualization. For example, to respect students' creativity and to give them room to think laterally, the weaker classification of space and discourse meant that no limits should be placed on brainstorming activity—after all, within the model, innovative ideas may emerge from apparently disconnected thought from outside the knowledge domains. In order not to pre-specify a product which the teacher had in mind, students were to be evaluated on what their designs featured, and not what the products lacked. Freedom was an implicit enabling condition of such liberal/progressive environments, and students were to be assessed on how well they exhibited the desired attitudes and dispositions, not necessarily on how much they knew about a certain knowledge domain. While all these pedagogic features were completely consistent and perfectly reasonable within the competence model, there are justifiable claims that can be made about the associated lack of knowledge development. Within the social realist framework and understanding of the role of powerful knowledges in society, there is a case to be made here that a sole focus on dispositions and attitudes, while admirable, should be considered fairly incomplete without the development of poweful specialist knowledges to back up these attitudes.

## 8.    Summary

To be sure, while these lesson observations do not record all lessons delivered by Bob in his class, they nonetheless represent a fair sampling of the pedagogical strategies used by Bob. At the very least, these observations are representative of the pedagogy selected by Bob to deliver, primarily, the STSE curriculum expectations, and associated thermal transfer concepts of conduction, convection and radiation. While Bob's case likely represents a near-best case scenario for environmental education in that a supportive, progressive ORF is paired with a PRF with high degree of autonomy and pedagogic philosophy directed toward the liberal/progressive competence model of recontextualizing, we see here that the outcomes of this combination does not lead to an increase in scientific knowledge gains especially if no deliberate effort is made to vary the semantic range of the classroom pedagogy with time. The fundamental tensions here are certainly not new and can be traced back as far as at least Dewey who argued for consilience between the false dichotomy of competing demands of the child and the curriculum (Dewey, 1902), and mirrored in a similar recent study which utilize the framework inherited from Bernstein (e.g., Sriprakash, 2010). The major knowledge gain from this case is in the use of Legitimation Code Theory to express the foundational concern with the cumulative knowledge modality and how such a mode may be achieved—by means of semantic variation with time.

# Chapter 8
# Strong classification and environmental education

## 1.    Introduction

In this chapter, I discuss the case of Clara, grade 11 university-track chemistry teacher teaching in a high school with a preponderance of visible minorities and recent migrants to the country. In part due to her cultural heritage and in part due to the strong academic orientation of the students in her class, the issue arises as to the optimum means of integrating environmental objectives in meaningful ways with scientific content—students were well aware of the strong boundaries between chemistry and other knowledges, and did not participate as fully during the segments of pedagogy concerned with environmental issues.

## 2.    Clara—Grade 11 university-track Chemistry teacher

Clara has had ten years experience as a teacher, and during the time when observations started, had been interviewing at schools for a curriculum leader/department head position. A daughter of visible minority immigrant parents (an engineer and a nurse), she nonetheless did well in school, excelling in the sciences and almost following her dream of becoming a doctor before she realized that medicine required a time commitment which was more than what she was prepared for. She then considered genetics research, before learning that in order to have the professional autonomy that she desired, she needed advanced degrees, which she was again not prepared to pursue. She also learned that she liked social interaction, and therefore found teaching an ideal job as it provided her a fair degree of autonomy, along with a fair amount of social interaction and her dealing with science, which she loved. When asked about the potential for schools to be social

levellers and agents for social change, she replied that she felt the larger influence to be the students' home cultures. She related an interesting anecdote of how her own father had "blackmailed" her sister, Debra: she had been stranded in a foreign country after an extended vacation away from school, and had ran out of money. Calling home to ask for emergency funds, their father had gotten Debra to agree to complete college as a condition to his paying for her return passage home. Clara had observed that among her students, class or race was not so much a determinant of academic success as home environment and parental expectations. Her school was located in proximity to Alice's elementary school; the school population was predominantly, in her words, "Black or Brown" (She justified using what may have been a borderline racial slur on the grounds that she identified herself as Brown). On three to four occasions over the course of the observations, there was a police cruiser parked at the school driveway, and somewhat chillingly, there were police posters on the entrance vestibule requesting witnesses to or information about a violent act against a student of the school. [Clara was to later tell me that that episode was a one-off occurrence, a student who brought trouble along when he transferred into the school]. In the general neighbourhood of the school, the predominance of ethnic grocers were a signal of the prevalence of visible minority groups. Perhaps as a consequence of her own home environment, she emphasizes competence and mastery in her lessons. She was of the opinion that environmental education and the science-technology-society-environment component of science lessons were often too large and unwieldily, and she preferred to have these components incorporated in bite-sized pieces throughout her lessons.

Clara was a helpful and resourceful colleague, and was the local 'worm lady', having had experience since her undergraduate days with vermi-composting. She helped the environmental club

set up an outreach program to the neighbouring elementary school even though she was supposed to be responsible for the school's Interact Club. She maintained a worm composting bin in her lab into which she regularly deposits food scraps. As she was not present at the PLC, I had spent more time with her during her planning sessions and directly assisted her in suggesting the lesson tasks. Her lab was not the usual style of rows of benches, but was rather a converted classroom; benches were placed on the edges of the classroom, and conventional classroom chairs and attached desks were arrayed in rows in a typical layout. The lab was not well stocked with glassware or chemical reagents, and the sinks were filthy, which appeared to match the rest of the school in the sense that the school appeared old and in need of repair at parts. In contrast to Bob's classroom, where objects available for students' manipulation were abundant, Clara's lab appeared to be in lockdown mode, with a bare minimum of equipment discreetly placed at the sides and front of the room. Even though she was no less friendly to her students, she did not tolerate students 'hanging out' in a corner while the rest of the class was working. She was a fan of demonstrations, and on one occasion bought a pack of flash paper, thin paper that had been impregnated with nitrocellulose, and for no particular reason (except that she was "feeling stressed and tired and wanted to see something cool"), lit strips of the paper in class, to excited oohs and ahhs of the students. This probably helped cement her reputation among students as the chemistry teacher whose classroom was full of explosions.

I helped her design a series of lessons that were centred on the chemistry topic of chemicals is society. We decided to use a media literacy approach, to get them to be more conscious and critical consumers. For starters, Clara showed three contemporary advertisements for hygiene products and makeup, the selling point of the ads being their products safe chemical composition. She

talked about these ads, how they used images of women to sell, what was not said in the ads, and prompted her students to think more deeply about them. As an activity, she gave them a series of print advertisements originating from the 1940s for Lysol used in feminine hygiene. Moving on from this to the main highlight of the series of tasks, she assigned them a project to research a chemical that was commonly used, find out its pertinent physical and chemical properties, environmental issues related to its use, and create a podcast that was to serve as a public service announcement.

## 3.    Teacher perspectives

Clara did not express the opinion that school knowledge was to be subordinated to the primacy of experiencing particular physical phenomena or enjoying their learning experiences. This was no doubt due in part to the age and course orientation of her students—they were Grade 11 university-track Chemistry students, for whom knowledge acquisition was prime on their agenda, with concrete ambitions to become engineers, doctors, dentists, or commercial pilots[30]. It was clear that Clara recognized this aspect of her students; during a planning session for one of the segments, we were discussing the tasks that the students were supposed to accomplish, and the discussion kept returning to the point that there was to be something that the students needed to learn out of the proposed activities. At one point, she suggested that:

> Maybe what we need them to do is look for claims, biases versus scientific facts. we need them to have a *strong connection to science*. Because what happens is, I love looking at biases, and scientific [inaudible] whatever, but if they feel it's not strong enough, then they're going to balk at it. They're fairly obedient, so they'll do what we want them to do. But I think that even when we're previewing the advertisements [in a previous lesson], I think some of them were thinking "what does this have to do with science?"

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30.   during one session, a casual discussion led to their telling me about their ambition.

Another contributory factor was the cultural background that she self-identified; as summarized above, she had been brought up in a culture that privileged learning and knowledge. She understood this to be the underlying guiding principle for herself and her students:

> See, in Asian culture, higher learning is of paramount importance [...] there are kids here, Asian kids whose parents are maybe not very wealthy, and that might be because, maybe they come from working class backgrounds, or maybe they're new to the country and have not built up their wealth yet. But there's a real intentionality to education being a way out. And the thing is that you could look at anybody you know and you can see strong evidence of that—this family wasn't doing so well, they sent their son to university, son is doing [inaudible] degree. Again and again, you see it all the time, it starts from very young, and they will do whatever they can to help their kids succeed academically. And Brown parents are the same way. Science, maths, are of paramount importance. It's just not really an option. There's positive and negative aspects. expectations are there. So, even if you are not making much money and you're brown, the likelihood of your progeny going and being successful and continuing is very very high.

Her comments are certainly not too far off the mark; prior studies by other researchers studying the immigrant attitudes towards education reflect similar attitudes (Lee, 1994; Li, 2001), although other studies point out that local school culture also contribute to the students' orientation towards school and knowledge (Kember & Gow, 1991; Watkins, Reghi, & Astilla, 1991). To be sure, these studies Significantly, and to be discussed in detail later, a recent study making use of the Legitimation Code Theory dimension of specialization (Maton, 2000a; Maton, 2007) studied students from China in Australian universities (Chen et al., 2010); this study largely corroborates the attitudes towards schooling expressed here. To be sure, it was not as though her students were completely intrinsically motivated towards her subject. The instrumental reason of obtaining credit in a course that was often a prerequisite for university programs meant that students would not identify themselves as being passionate about Chemistry:

> I did a four corners activity with my chemistry class, I was shocked with the results. So I made a statement: How much do you like chemistry? One corner: I hate chemistry. Second corner: Indifferent. Third corner: I really like it. And fourth corner: I love

chemistry. I was alone in the love chemistry section. There were 3 people in the 'don't like it' [corner]. The majority of the class was indifferent. And I'm just like, okay, well, I'm not insulted by this, because I have not taught you yet. But this is an elective course. I'm surprised that more people don't really, at least, like chemistry, if it's not your favourite subject [...] To me, the four corner activity is a challenge to me—Can I get them to the point where those grade 11 students are just like "I LOVE CHEM-ISTRY". If I can get them to tap in and be excited about something that I'm excited about, that's very successful.

As a teacher, Clara felt that she had only limited latitude in changing the classroom curriculum and pedagogy before students recognized that they were no longer 'doing science'. Because of the numerous years in schooling, her students were clear of the strongly classified disciplinary boundaries between the school subjects. Perhaps in line with their lack of passion and instrumental relation to the subject, they were not eager to learn any more than the necessary to get by:

Last semester for example, [...] every Wednesday, I made sure, at least once a week, there was a lesson that involved environmental education in my chemistry class [...] if I go into biology class, and I do environmental whatever, the students eat it up, they love it, whatever. They were like, "I wanna learn about this!" You do that in chemistry class, they'd be like "why are we doing this? This is not biology class, I don't give a crap about this" I'm not even kidding you. To me it's very obvious that environmental chemistry is an important strand in chemistry, and as chemists we should be really concerned about the impact of chemistry in society; it just seems too obvious to me, but very [pause] difficult to convince them of that. It's so compartmentalized.

The strongly classified boundaries between the knowledge domains were also experienced by Clara at the level of the organization of the school faculty:

One of problems, at high school, Huge division between departments, what happens is that there is overlap, but we don't know where the overlap is. I showed a video about climate change, half the class was like "I've seen it in geography!". I hardly ever show videos, and the one good video I show, they've seen it. What you were talking about, it's very much a science topic, but it's [also] very much a globalization, geography, social science topic, and it wouldn't be taught in science. And I think it should be taught in both science and social science, but I don't think it ever will be. Unless it was just touched on briefly.

At the initial interview, she had expressed enthusiasm at my presence in her classroom, as she welcomed additional perspectives towards the resolution of a long standing issue for her:

> Yes, well that's a big reason why I'm not doing it [environmental education] in Chemistry, because there's no natural insertion point. Well, there is, but they're sort of small and people collect them up [...] The thing is that the environmental education insertion—it's just like anything else, right? Why don't I do more inquiry? Why don't I do more of this? Why don't I do more of that? On some level, I reproduce exactly what was taught to me, how I was taught, right? So if I didn't have that... I'm not blaming anybody, but I'm just saying that, if I was taught that, in a way that we explore these kinds of issues, in a big project, that is what I would also do. And so, I believe that it should be incorporated in a more everyday way, but everyday kind of gets in the way [of] itself.

As she expresses it, environmental education, STSE education, or the general principle of encouraging students to take practical action to resolve sociopolitical issues in their lives has mostly become lost in the numerous demands that the different governing agencies for schooling routinely issue to teachers; it becomes "more of this... more of that..." This list included, from her perspective, inquiry pedagogy, critical thinking, the use of Info-Communication Technologies in the classroom, taking into account multiple intelligences in classroom teaching, among others.

Clara expressed anxiety regarding encouraging her students to take practical action in her classroom. She had previously got into a bit of trouble when she started teaching because, in her youthful zeal, she had told her class about the way that technology was changing social life, and how people dated and got into long term relationships. A parent had called the principal to complain about a disagreeable interpretation of her message, and while the situation was quickly resolved, the episode left a bitter taste in her mouth, and she was now reluctant to move without some support from administration:

> At OISE there are a lot of "let's be an activist" themes. Teachers, and myself included, are very nervous; we're getting this message from OISE, but yet, I don't know if we've

resolved something that we might get into trouble with. If the school had rubber stamped its approval, maybe we would do more [controversial issues] [...] I don't know, as a teacher, I'm a little nervous. I sometimes think as teachers we're supposed to be neutral. When you get into the socio-political game, that's not neutral, when you're saying to kids, write a letter to the newspaper, I would have no problem doing that, but it's biased. What if the kid does not want to write a letter to the newspaper [.] Because they believe that climate change is total crock? What is their assignment then? You know what I mean? [...] I guess it puts me in a grey area. The message from OISE was very clear that we should do that socio-political action, but I don't think the word from the ministry or the board is that clear. In fact it's not, if you look at the curriculum document—it's not.

Even with support in the design of the curriculum, Clara was reluctant to spend more than one session for the Lysol task, and three for the podcast assignment. This was not because she was unaware or not concerned about the state of the natural environment; she actually possessed a rather well-informed view of the environmental problem:

Clara: I think that there's been a lot of overexposure about environmental issues [...] everybody is using green this and green that.

Michael: Greenwashing?

C: Yeah that's right. There's been a lot of airtime and people are worried, but is anything changing, or are things really worse than they were maybe 5 years ago? Every year is worse as more species are being wiped out or the air is getting more polluted or whatever [...] Well, the other thing too, is what do people do about it? At the end of the day, people are like, let's recycle more. You're missing the point. How about you stop shopping. But nobody ever suggests that, that actually can have a very very good effect.

M: In that case, what do you think should be done [for environmental education] instead?

C: I think we should look at the larger issues, we should be also looking at more what people personally can do and what collectively we can take our small actions to make larger changes. So if we all decided that we all didn't need to buy computers every 2 years and we refused to do it, and people were really writing about that, then maybe the computer companies would respond by making computers that last a lot longer.

M: What do you think environmental education should look like in the classroom?

C: I really think that we should be looking at some social issues in combination with EE, and I've never done that before. And it's difficult. Well, I don't know if it's difficult, but I just don't know where to start, right? And the thing is that you don't know where the students are coming in with [...] Much more attention should be paid around consumer choice, and not just like I will take my lunch in my tupperware container, or I will recycle my coke zero can, but much beyond that. Or like looking at [.] basically looking beyond recycling. And looking beyond catastrophe in the world, everything is going to die, all the species are going to be wiped out. Because in the end you just feel a sense of hopelessness.

On balance, as we shall see in the following, her efforts at environmental education are probably meagre in comparison to her teaching of the basic scientific concepts. Clara's case represents the typical context of a senior grade high school academically oriented pedagogical situation—with students close to completion, generally motivated the acquisition of school knowledge, and the demands of knowledge transmission putting pressures on teachers to deliver the curriculum such that they spend little time away from basic content.

## 4.    Curriculum overview

The lesson observations for Clara's class took place over thirteen weeks. During this period, several strands were covered, including *Matter, Chemical Trends, and Chemical Bonding* (whose major idea was elemental periodicity), *Chemical Reactions* (major idea: different types of chemical reactions), *Quantities in Chemical Reactions* (major idea: the mole concept), and finally, *Solutions and Solubility* (major idea: acid-base reactions, stoichiometry). Because of the strong content emphasis in Clara's class, only four complete lessons (out of 17 recorded in total) were spent on activities which developed the STSE learning objectives, and they were to be found in the *Solutions and Solubility* strand. There were two other sessions where Clara discussed ideas about environmental issues, but as these appeared to be digressions away from the ongoing strand, these strands will not be ana-

lyzed here. Side by side, the differences between the older version of the curriculum (from 2000) and the most recent revision (2008) are highlighted below:

| Older curriculum | Newer Curriculum | Comments |
|---|---|---|
| describe the dependence on temperature of solubility in water for solids, liquids, and gases | explain the effects of changes in temperature and pressure on the solubility of solids, liquids and gases (e.g., explain how a change in temperature or atmospheric pressure affects the solubility of oxygen in lake water). | Increase in content expectation—additional of the 'pressure variable". |
| demonstrate an understanding of the Arrhenius and Brønsted-Lowry theories of acids and bases | explain the Arrhenius theory of acids and bases | Arrhenius theory is older, more limited model for explaining the behaviour of acids and bases. The Brønsted-Lowry theory has a great explanatory utility. Brønsted-Lowry theory deferred to Grade 12 strand *Chemical Systems and Equiibrium.* |
| demonstrate an understanding of the operational definition of pH (i.e., pH = –log10[H+]). | use appropriate terminology related to aqueous solutions and solubility, including, but not limited to: concentration, solubility, precipitate, ionization, dissociation, pH, dilute, solute, and solvent | expectation moved from "Understanding Basic Concepts" section to "Developing Skills of Investigation and Communication", and diluted with other concepts. Less prescriptive language used—"including, but not limited to". |
| determine, through experiments, qualitative and quantitative properties of solutions (e.g., perform a qualitative analysis of ions in a solution; plot solubility curves for some common solutes in water), and solve problems based on such experiments; | conduct an investigation to analyse qualitative and quantitative properties of solutions (e.g., perform a qualitative analysis of ions in a solution) | Change of language—from "determine through experiments" to "conduct an investigation", and reducing the number of suggested experiments/investigations. |
| determine through experimentation the effect of dilution on the pH of an acid or a base; | prepare dilutions using concentrated solutions, and observe or measure the changes in properties (e.g., pH, colour, viscosity, density) | modified expectation with potentially expanded range of investigation required of students. |
| write balanced chemical equations for reactions involving acids and bases (e.g. dissociation, displacement, and neutralization reactions) | write balanced chemical equations to represent the chemical reactions involved in the neutralization of acids and bases. | Revised expectation is in another strand—*Chemistry in the Environment* for Grade 12 College preparation. Essentially, for university preparation track, this expectation is deleted. |

| | | |
|---|---|---|
| supply examples from everyday life of solutions involving all three states (e.g., carbonated water, seawater, allows, air) | expectation deleted | older curriculum is low on the semantic range |
| describe examples of solutions for which the concentration must be known and exact (e.g., intravenous solutions, drinking water) | expectation deleted | older curriculum is low on the semantic range |
| explain the origins of pollutants in natural waters (e.g., in landfill leachates, agricultural run-off), and identify the allowable concentrations of metallic and organic pollutants in drinking water | analyse the origins and cumulative effects of pollutants that enter our water systems (e.g., landfill leachates, agricultural run-off, industrial effluents, chemical spills) and explain how these pollutants affect water quality | approximately equivalent expectations, but sample issues and questions are axiologically charged. See discussion below. |
| describe the technology and the major steps involved in the purification of drinking water and the treatment of waste water | analyse economic, social, and environmental issues related to the distribution, purification, or use of drinking water (e.g., the impact of on the environment of the use of bottled water). | Sample issues and questions presents issues which are axiologically charged. See discussion below. |
| explain hardness of water, its consequences (e.g. pipe scaling), and water-softening methods (e.g. ion exchange resins) | expectation deleted | older curriculum is low on the semantic range |
| expectation not present | conduct an investigation to determine the concentration of pollutants in their local treated drinking water, and compare the results to commonly used guidelines and standards (e.g., provincial and federal standards) | |

Table 8.1: Curriculum comparison, Grade 11 university-track Chemistry. Strand title: Solutions and solubility

Overall, the curriculum documents appear largely equivalent, with similar content coverage, and minimal content reduction in the "Understanding Basic Concepts" section of the revised curriculum. However, the most significant change is to be found between the STW/STSE sections. As observed in the table above, some of the older more context dependent knowledge expectations

in the STW section appear to have been deleted to make room for a more sophisticated discussion of issues, and in a fashion true to the STSE principles, brings in analyses linked to other knowledge domains (e.g. economics, sociology, human/urban geography). While this is development that should be welcomed, the sample issues suggested by the curriculum uses language with heavy axiological charging (Martin, Maton, & Matruglio, 2010)—in other words, language calculated to invoke a strong emotional response, as in the following:

> Golf courses use fertilizer and irrigation systems to sustain the vegetation. However, chemical substances, when combined with water, may run off and pollute local water systems.

The use of "golf courses" as an example of a source of pollution of "local water systems" draws from a reserve of public resentment related to the unequal distribution of wealth in society—for the most part, golfing at clubs that can afford grounds where "fertilizer and irrigation systems" are in use (as opposed to driving ranges, for example) remains a fairly exclusive activity that only the somewhat wealthy can afford. When phrased in this manner, one can detect a sense of moral outrage at what is effectively the equivalent of a few rich people poisoning water systems that everyone else needs, for their own selfish leisure pursuits. While this document was prepared before the 'Occupy' movements of 2011 gained public interest, is is clear that this issue draws from the same well of sentiment—that income distribution is unfair, and the wealthy are abusing their positions of privilege at the expense of the common man. Certainly there are less charged examples that one could use? Fertilizer run-off from agricultural plots or salt run-off from highway ice clearing operations are well studied examples and presents issues which everyone contributes to, regardless of one's state of wealth; analyzing this issue certainly problematises one's own actions, rather than

simply directing anger at certain fractions of the population. Perhaps slightly more disturbing is the sample issue for the other STSE specific expectation:

> In developing countries, thousands of people, many of them children, die every year from drinking contaminated water. Many of these countries cannot afford to build water treatment plants. In North America, where safe water is generally available, we spend millions of dollars on bottled water, draining sources of fresh water and challenging waste-disposal systems.

Here, the language is even clearer as to its intent at emotive persuasion, especially in its use of the language of "tragedy, malfeasance, and ignorance" in the form used in Alice's classroom. For example, there is little reason to including the phrase "many of them children"—surely the deaths of thousands of people is a bad enough tragedy, unless one wants to specifically tap into a key phrase often used as a trump card in many political debates[31]. There is understandable concern over the issue of bottled water, and it is probably arguable that a neutral position here is not tenable. Yet, the phrasing of the issue essentially simplifies and conflates two different issues with different underlying causes and possible solutions into one that is unidimensionally economistic—the subtext of the statement is that the affluent North Americans should stop the malfeasant practice of drinking bottled water and instead spend the "millions of dollars" in building water treatment plants in tragic "developing countries" which simply "cannot afford" them.

Here, there is reason to not overdo the critique—after all, a nuanced and balanced treatment of these issues are properly the domain of another discipline like sociology which has more sophisticated concepts to deal with such social phenomena as unjust economic distribution, or psychology in dealing with the way marketing agencies have planted fear and distrust of municipal water sys-

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31. e.g., in February 2012, Canadian Public Safety Minister Vic Toews introduced a bill whose purpose was to, among other things, allow warrantless internet surveillance. In public statements, he suggested that people could "either stand with us or with the child pornographers" (Ibbitson, 2012)

tems, and instead glamourized what essentially are bottled versions of the same thing. The critique is directed at the underlying philosophical motivations for wanting students to deal with these issues: at the level of intellectual maturity of these students, it is surely an underestimation bordering on condescension to not deal with the significant intellectual ideas surrounding these issues. Yet, if one were to pursue such a course of action, the science lesson strays away from being one, and not all teachers will be comfortable with teaching these ideas.

## 5.    Semantic profile

Because Clara privileged the teaching of scientific concepts in her lessons, and allocated only very limited time for the discussion of STSE/environmental education related knowledge expectations, the discussion in this section will be concerned with providing a representative sampling of her scientific content pedagogy, and then analyzing her STSE/environmental education pedagogy in detail, also discussing the tasks assigned to the students, as a significant amount of the work assigned to her students were to be done as homework, prior to attending the next lesson. Clara's scientific content pedagogy was fairly typical of what Bob would have termed as 'industrial'—the lecture-tutorial method commonly used for students at this age—since there was a lot of material to explain to her students, a most efficient manner would be to utilize teacher-fronted lectures, with her writing essential examples and definitions on the chalkboard. After these lectures, students were assigned problems which they were supposed to work through, either in class, or if time was insufficient, at home. At the next session, she would review the problem set, highlighting specific questions that were especially difficult or demonstrated certain aspects of the content she was teaching. A series of lessons she delivered on the *Solutions and Solubility* strand progressed as follows:

| Lesson/ Phase | Description | Coding/Comment |
|---|---|---|
| | **Lesson 1** | |
| Phase 1 | test taking: Summative exercise for previous unit | SG–/SD+/ESR: High: students answer theoretical and abstract questions regarding the chemical principles of molarity. |
| Phase 2 | Lecture: Clara introduces chemical equations describing typical hard water situations, reactions between soap and particular ions present in hard water to form soap scum. | SG–/SD+/ESR: Decreasing: Clara starts by introducing the abstract equations, and then begins to talk about realistic scenarios where the knowledge of these equations explains the scenarios, e.g., scale in kettles, bathtub soap scum. |
| Phase 3 | Individual seatwork: Students work with solubility rules chart to answer some practice problems | SG–/SD+/ESR: Decreasing: Student practice facilitates contextualizing of abstract principles learnt in earlier phase. |
| Phase 4 | Pair work: Planning for inquiry activity: How to soften hard water | SG+/SD–/ESR: Decreasing: Designing aspects of a highly contextualized practical activity |
| | **Lesson 2** | |
| Phase 1 | Teacher demonstration: *The Water Story*—A large (5*l*) beaker is filled with "lake water", and students each hold a small (50 *ml*) of "contaminant" (e.g. "motor oil", "industrial effluent", "fertilizer runoff"—all safe/edible substitutes). Students take turns to empty their contaminant into the 'lake' as a story is told about how the water makes its way through major rivers, picking up contaminants along the way. End result is a murky beaker designed to evoke visceral responses. | SG+/SD–/ESR: Low: highly contextualized demonstration of water pollution. |
| Phase 2 | Student laboratory session: in pairs students take samples of "hard water" and perform qualitative analysis to determine the ions present in their sample. Clara circulates to direct and assist students | SG+/SD–/ESR: Decreasing: contextualized activity where students make use of general principles and solubility charts to 'see for themselves' how these ideas are implemented in a practical activity. |
| | **Lesson 3** | |
| Phase 1 | Lecture/ IRE discussion: on worm composting and waste diversion. | SG+/SD–/ESR: Low: See detailed comment below on worm composting. |
| Phase 2 | Individual seatwork: Students work on completing the inquiry activity from the day before | SG–/SD+/ESR: Increasing: Students are generalizing results of empirical investigation and writing up their reports in scientific/technical language. |

| Phase 3 | Demonstration: Clara assists a student who was absent the day before with the activity, and a group of 9 other students gather to watch. Other students continue working on their reports | SG+/SD−/ESR: Decreasing: As with previous day, making use of general principles in a particular context. |

| Lesson 4 | | |
|---|---|---|
| Phase 1 | Lecture/IRE discussion: Review of laboratory activity | SG−/SD+/ESR: Increasing: Clara synopsizes the pertinent details of the laboratory session fro the previous lesson, paying attention to particular practical laboratory techniques, and theoretical principles which underlie the practical observations. |
| Phase 2 | Lecture: on solution concentration | SG−/SD+/ESR: High: Clara teaches from the text, with occasional examples drawn from accessible phenomena to illustrate theoretical principles. |
| Phase 3 | Demonstration: a copper coin in concentrated sodium hydroxide solution and zinc powder is boiled; zinc coats the copper coin | SG+/SD−/ESR: decreasing: Empirical phenomena to illustrate the general theoretical principles introduced |

| Lesson 5 | | |
|---|---|---|
| Phase 1 | Lecture: preview to Lysol task: Clara previews the activity (see details below) | SG+/SD−/ESR: Low: Clara talks about the use of Lysol in concrete terms. |
| Phase 2 | Individual seatwork: Students are assigned worksheets to complete in class. | SG−/SD+/ESR: High: worksheet deals with sophisticated concepts in solution chemistry. |

| Lesson 6 | | |
|---|---|---|
| Phase 1 | Lecture: Clara gives an overview of the Lysol task, and the task requirements | SG+/SD−/ESR low: context specific instructions |
| Phase 2 | Individual seatwork: Students research Lysol and other related information using the internet. | SG+/SD−/ESR: increasing: students need to condense specific research materials into generalized representations to include in their writing task. |

| Lesson 7 | | |
|---|---|---|
| Phase 1 | Classroom management: Clara chides her class for not taking the Lysol task seriously, and submitting work on time as required. | SG+/SD−/ESR: Low: not content related talk. |

| | | |
|---|---|---|
| Phase 2 | Lecture: strong and weak acids, introduction to pH. | SG–/SD+/ESR: High: Clara discusses sophisticated chemistry concepts, with occasional examples that are lower in semantic range. Overall, the semantic range of this phase is high. |

<table>
<tr><td colspan="3" align="center">Lesson 8</td></tr>
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| | | |
|---|---|---|
| Phase 1 | Lecture: Overview of podcast task (see below for details), and task requirements | SG+/SD–/ESR: Low: Task specific instructions |
| Phase 2 | Group work: In groups of 3, students brainstorm and research for materials online | SG–/SD+/ESR: Increasing: Students condense information from diverse sources in order to make their case for the project. |

<table>
<tr><td colspan="3" align="center">Lesson 9</td></tr>
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| | | |
|---|---|---|
| Phase 1 | Lesson review: Clara guides students on a paired activity to prepare them for an upcoming test | SG–/SD+/ESR: High: Class clarifies abstract concepts for their test. |

<table>
<tr><td colspan="3" align="center">Lesson 10</td></tr>
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| | | |
|---|---|---|
| Phase 1 | Podcast recording: Students take turns in quiet room to record prepared scripts into a digital format for later editing | SG+/SD–/ESR: Low: Practical activity. |

<table>
<tr><td colspan="3" align="center">Lesson 11</td></tr>
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| | | |
|---|---|---|
| Phase 1 | Podcast recording: Students take turns in quiet room to record prepared scripts into a digital format for later editing. Continuation of previous lesson. | SG+/SD–/ESR: Low: Practical activity. |

Table 8.2: Coding summary for Clara's unit in Solutions and Solubility

To summarize, Clara's pedagogy in scientific content follows a somewhat typical trajectory that is commonly found in teaching at this level. In some way, Bob's characterization of these pedagogical techniques as being 'industrial' is not far off the mark: In order to reach as wide an audience as efficiently as possible, techniques and organizing logic from industrial practice were borrowed and have become the norm for school. Because Clara is an experienced teacher, she had little problem with managing the cumulative modality—the series of pedagogical moves to periodically weaken semantic gravity and strengthen semantic density, followed by the reverse. Because there was a strong

emphasis on the scientific content in Clara's class, the typical wave-like pattern of the semantic range of her scientific content lessons had peaks of somewhat equal height. During sessions devoted to STSE expectations however, the relatively strong classification between chemistry and environmental knowledge expectations meant that there was minimal semantic relationship between these domains, and the semantic profile during STSE segments of her class resembled that of Bob's (see Figure 7.2, p. 221)—a 'broken escalator' (Maton, 2011a), where theoretical abstractions are contextualized and exemplified by empirical phenomena, but this phenomena is not really used as a means to 'launch' off into the building of another abstract concept. Below, I will discuss the activities planned and implemented for STSE expectations in some detail.

## 6.     STSE activities—Lysol, Podcasts

In Clara's class, activities directed toward the development of STSE specific expectations were strongly distinguished from her 'normal' pedagogy for scientific content. This distinction was so sharp that there were at least a few occasions (e.g. Lesson 3, Phase 1) where she abruptly changed topics from a discussion on periodicity with strong student involvement in the discussion, to a discussion on waste diversion and worm-composting where students suddenly fell largely silent. While student perspectives were not solicited for this project, it was clear that students were highly conscious of the strong boundaries that existed between "chemistry knowledge", and other knowledge which was held at a slightly lower level of respect. Definitely, this was what Clara surmised when she said she felt that her students often "did not give a crap" about environmental knowledge; this near apathy was probably contributory to her classroom management session in the beginning of Lesson 7 where she chided the students for not being serious about submitting completed work.

### 8.6.1        Lysol task

For the activity that we eventually came to call the 'Lysol task', I came across a series of advertisements for Lysol from the 1930s. During this period, Lysol was widely advertised as a (largely ineffective) means of birth control. Because of the social mores present at that time, directly advertising Lysol as birth control would not have been acceptable, so clever euphemisms and code words were used to signal its intended use. An example of such an advertisement is shown below (see Figure 9.2, p. 298), with the advertisement copy reproduced in the right column. The task for the students followed a typical media literacy lesson plan—critique an existing advertisement in terms of its biases, (possibly fraudulent[32]) claims, and assumptions. Because Clara was concerned with the scientific content, she had the students also research the active ingredients of Lysol (alkyldimethylbenzylammonium chloride, ADBAC or benzalkonium chloride, a mixture of alkylbenzyldimethylammonium chlorides of various even-numbered alkyl chain lengths), and also the standard measures for toxicity, and how Lysol could be hazardous to the environment. Eventually, the students were supposed to write a persuasive letter to a fictitious friend to convince her to stop her practice of using Lysol as a vaginal douche. The task questions are listed in Figure 9.3, p. 299.

### 8.6.2        Podcast task

For this segment of her lesson, Clara specifically wanted to try out the process of podcast production, because it was something that she had always wanted to try, especially since she attended a workshop about producing podcasts and found out how straightforward it was. Clara acknowledged that fundamentally, this process was not unlike having students present their work to the

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32. In the Lysol ads, was a claim that "European" doctors recommended the use of Lysol as a vaginal douche. The American Medical Association actually investigated, and found these claims to be fraudulent.

class, except with the addition of a technological layer which could either attract the attention of students due to the novelty of the task, or potentially complicate matters when technical issues inevitably crop up. Because I was present in her class and was able to render technical assistance if required, she thought to try this activity. Designing the questions (see, Figure 9.4, p. 300), Clara wanted the task to address the STSE expectations, but at the same time, did not want to excessively delimit the scope for her students' research. In the end we arrived at the list of possible issues to research and produce a public service announcement podcast.

## 7. Discussion

In contrast to the competence model of curriculum recontextualizing demonstrated by Alice and Bob, Clara demonstrated a performance model for her scientific content pedagogy. Time/space/discourse were strongly classified: Clara kept a very tight schedule and insisted that the STSE expectation be completed within a short time, students were seated in traditional rows (on old combination desk-chair units) and did not move about in class, and the discourse in class was strongly classified, being the scientific discourse on solutions with high degrees of technicalization and abstraction. In other words, it was not possible to mistake the class for, say, a history or literacy classroom, especially when the discourse elements are considered. Evaluation was based on whether or not students acquired mastery of the knowledge content of chemistry. Classroom control was explicit; with Clara tightly controlling the activities in the class and the students being more experienced and successful in schooling, the students mostly acquiesced in this arrangement. The pedagogic text assessed was the student performances, of which presences were privileged—students had to demonstrate understanding in solving the puzzle-like problems they were assigned, and even for the podcast and Lysol tasks, deliberate guiding questions were set up so that students' answers

could be directed toward the production of a desired text. Students' autonomy was relatively limited, for example in the podcast task, they were encouraged to choose between a few options presented to them from a list of possible topics to conduct their research on. On the other hand, Clara reported having a high degree of autonomy in her position. Like Alice, she was a well respected member of the school faculty, and was preparing for promotion to curriculum leadership position, likely in another school. On top of that, she was the only teacher for chemistry for the grade 11 students; as such, she did not feel the pressure to conform to team teaching standards or selection, sequencing and pacing as she reported when I visited her after the study, and she had transferred to another (larger) school. Clara's pedagogy could be considered to be rather high economy/ low cost, in that the privileging of explicit transmission of knowledge "makes such modes less dependent upon personal attributes of the teacher and so their supply is less restricted. Accountability is facilitated by the 'objectivity' of the performance and thus outputs can be measured and optimized" (Bernstein, 2000, p. 50).

Because of the strongly classified nature of classroom discourse, students were very aware of the disconnected and almost intrusive nature of STSE expectations in the normal flow of the chemistry classroom. Besides the students' reactions to the topic of vermi-composting mentioned earlier, the Lysol task was also poorly done, with almost all students handing in incomplete work, and student response not achieving the depth of analysis that Clara had judged that they were capable of (when she was designing the tasks). For the podcast task, students responded with more enthusiasm, but that may have been due to their working with podcast production, a novel activity that brought them away from the humdrum of normal activity. The class response to the Lysol task was so poor that Clara actually took time during class to remind them of the importance of the

tasks (Lesson 7, Phase 1). Consistent with the performance model of evaluation orientation, she commented on how she underscored the importance of the vermi-composting lessons to her students:

> I talked about vermicomposting to my students over the years, and they're always very interested. Not everyone, some people don't care [...] This time, I'm proud of the fact that I had an article to show them, they read it, you saw how they reacted; my lesson plan for the day was completely different. I was planning to do some basic chem, but they read about it, talked about it, and were really ready to see them [the worms] and interested in it, that was very cool. **But what made a difference is that I made them do a marked written tes**t, where they read something prior to looking at it, and where they were actually assessed. We were talking about this in STSE and all these kinds of things where students think it's some additional thing that's not going to count. If it doesn't count then it doesn't mean anything, really. And then so they just brush it off. (emphasis added)

The picture that emerges from statements like this is that Clara's students lack the same enthusiasm as Alice's elementary students for STSE/environmental learning objectives during her class. However, it is not as though students were apathetic about these causes in general—several of her students were also active members of her local "worm outreach" project, bringing worm-composting to the local elementary school, and serving as mentors for the younger students. Here, it is probably more accurate to surmise that students held the attitude that STSE/environmental objectives do not belong in chemistry class. However, since no student perspectives were elicted, this conjecture remains just that.

Again, because the classroom pedagogy for scientific content was strongly classified, STSE expectations were inadvertently signposted as "not chemistry" (and therefore not as important), not with explicit references and Clara pointing out, but with changes in activity structure, task expectations, and type of knowledge. In contrast to the largely individual work that was expected of the chemistry content knowledge, the podcast task was a group activity. Instead of showing compet-

ence with theoretical knowledge, students had to make use of their creative abilities to design a podcast that had high aesthetic value which could appeal to public sensibilities. The knowledge processing required of the students was distinctly different: while scientific content required them to understand challenging concepts to apply in challenging novel contexts as in the problem sets they were assigned, the STSE tasks were largely concerned with having students compile publicly accessible information that they gathered online. While critical analysis and commentary were desired outcomes for the STSE tasks, there simply was not enough time for students to have developed a sufficiently developed and nuanced understanding of the issues that they chose. The Lysol task was done within two periods, and the podcast within four periods. Clara acknowledged that the podcast task was fundamentally a classroom presentation, dressed with a technological veneer.

A problem here becomes the explanation for the students' apparent apathy, or at least, lack of enthusiasm, toward environmental causes. While the strong classification of knowledge boundaries between scientific content and STSE knowledge domains explains how students have no difficulty distinguishing between the two, it does not explain the differential valuing of the different kinds of knowledges. A possible explanation lies within Clara's observation of the privileging of knowledge that she believed members of particular visible minority groups held. Of 16 students in Clara's class, only one was of European descent; the students were primarily from East and South Asian migrant backgrounds, and a handful of them were recent migrants. Specifically, from her perspective one could make the case that her students paid more attention during the scientific content segments of her lessons because they could tell that these segments were times when powerful knowledges were being communicated. It is likely that these valuations are learned from

strong familial and cultural influences. For example, a study by Li (2001) of Chinese-Canadian immigrant parents' attitudes towards education cited a parent:

> I do not support my daughter to become a lawyer. In Canada, although multicultural-ism is written into the government policy, you can feel racial discrimination everyday, everywhere. It's very common. Minority groups, especially visible minority groups are in a very disadvantaged situation ... I advise my daughter not to choose lawyer as a ca-reer because a lawyer represents justice, but how can you argue with the dominant soci-ety if they believe that the "truth" is on the side of the white majority, not on the side of visible minority? It will be very difficult for my daughter to pursue such a career. If she wants to become a doctor or a computer expert, that will be easier. (Mrs. Yu) (p. 486)

Li found that parents encouraged their children to take up careers in science, engineering and the technical professions, and discouraged them from taking up the fields of arts, politics, and law. Within the explanatory framework of this study, such advice becomes easily accounted for—for immigrants struggling to cope with the demands of assimilation and a fuller participation in the host culture, learning the knowledges of the powerful constitutes a more difficult challenge than acquiring powerful knowledges, for which they may have had prior school experience. In other words, for the many new migrant students into the country, science and technology are attractive knowledge domains to acquire competence in. Subjects like art, history, literature or other hori-zontally structured knowledges reflect the interpretive biases and socio-cultural specificities of local communities; acquiring competence in these knowledges requires the acquisition of a culturally specific gaze. On the other hand, hierarchically structured knowledges like science, technology, en-gineering and mathematics remain the same even if they first learnt it in Wuhan, Kolkata or Mindanao. Hierarchically structured knowledges can be said to weakly classify learners' identities—who students are in relation to the scientific knowledge does not matter. Conversely, for horizont-ally structured knowledges, learner identities are more strongly classified—the goal for horizontal

knowledges is the inculcation of the identity of the desired knower, exhibiting particular favoured moral, political and social dispositions and attitudes, in this case, a pro-environmental stance. In this regard then, when the strongly classified and framed discourses of chemistry are substituted for the weakly classified and framed STSE, students notice the change, and respond appropriately to what is deemed as subordinate knowledge.

Here, while the analysis has considered the immigrant perspective, there are reasons to believe that non-migrant, non-visible-minority students would also behave the same way. This class was an elective course, and students who would choose it would likely do so because of its perceived exchange value in obtaining access to certain professions, if not for the love of the disciplinary knowledge itself. In either case, if STSE knowledge is not recontextualized in a manner that creates seamless transitions between itself and the disciplinary knowledge, the uneven nature of such a combination will likely lead to minimal gains in environmental education. While the PRF has a large part to play in the final stage of recontextualizing knowledge to meet the requirement of semantic 'seamlessness', the ORF, in its production of an official curriculum document which prescribes precise knowledge expectations also needs to make sure that these expectations either allow teacher sufficient latitude for their interpretation, or that these expectations are, in the first place, meaningfully connected to the scientific content.

## 8. Summary

Clara's case presents an interesting counterpoint to the cases of Alice and Bob, for whom content knowledge was deemed of secondary importance to attitudes towards learning, and the transmission of societally favoured dispositions. To a large extent, these differences may be attributable to the grade level differences—for Clara's students at grade 11, on a university track academic ca-

reer, it is largely taken-for-granted that the values that Alice and Bob were inculcating in their students would have been internalized and hence little attention was needed in this respect. Socio-cultural perceptions of the goals of schooling may also contribute to this relative valuation of knowledge over the dispositional aspects of schooling. Given this context, and the fact that most environmental or STSE issues remain complex enough that a sufficiently non-pedestrian treatment would be difficult to implement in the classroom, STSE/environmental issues tend to taught in a disconnected manner from the regular scientific content, and become interpreted as "not science". Generally speaking, considering the relative location of the STSE and scientific content expectations on the semantic range, there exists the potential for STSE expectations to function as effective empirical referents to abstract scientific content. However, partly because the STSE expectations *in the curriculum document* are imbued with a strong ethico-moral persuasion objective, and partly because typical pedagogical approaches cause the disconnect to become apparent, STSE/environmental education learning objectives do not function as well integrated logical outgrowths of scientific knowledge, but only as peripherally related tragic circumstances that result from the malfeasance or ignorance of people.

# Chapter 9
## Discussion and conclusion

In this chapter, the intent is to adopt a reflective stance, to look back at the study and identify what may be certain shortcomings, and through the process, make certain prognostications as to future avenues for productive research. I also take the opportunity to discuss two general issues that emerge from this study—specifically, the importance of knowledge to science, and the interaction between knowledge and learner identities.

## 1.    Summary of findings

At this point, it is perhaps useful to recapitulate the research questions that this research set out to explore; recall that in the light of political changes that foregrounded the importance of environmental education in the school curriculum, I had set out to answer the following:

• What are the effects of the curriculum revisions on the knowledge content of the science curriculum?

  – Comparing between the current version of the elementary science and technology curriculum with its immediate predecessor, what is the nature of changes made to the curriculum?

• What are the characteristics of science pedagogy in fulfilment of these curriculum changes?

  – Considering the influence of the curriculum document on classroom pedagogy, what are the effects of teachers satisfying the curriculum expectations on the level of scientific knowledge in the classroom?

In the first part of this study, I have shown through the curriculum analysis that the revision to the science and technology curriculum has resulted in a curriculum document that has deprivileged scientific content knowledge. This has been done by a combination of curriculum content reduction, a shift in the type of learning objective from more context independent, abstract knowledge forms to more contextualized, concrete forms. The degree of symbolic condensation has also been reduced—learning objectives have been re-written in 'simpler' language with reduced technicalisation. Learning objectives have also been modified such that the revised curriculum has more expectations which are concerned with deductive demonstration of theoretical principles, rather than the older curriculum where more attention was directed toward building generalizing principles. Overall, the STSE expectations appear to have a 'disconnected' relation to the scientific content. These expectations, while not totally unrelated to the scientific knowledge, tend to be tangential knowledge propositions only marginally related to the scientific knowledge.

In the second part of this study, I consider what may be consequences of such a change in the curriculum when it undergoes a further stage of recontextualization at the Pedagogic Recontextualizing Field. Of three teachers studied, two exhibited the competence model of recontextualization, while the third used a performance model. From the case of Alice, we see that while a combination of liberal /progressive ORF and PRF may be ideal for the transmission of certain valued dispositions and attitudes towards the environment, such attitudes do not necessarily have positive effects for knowledge acquisition. By focussing on the tragedy, malfeasance and ignorance of environmental issues, students may be urged to take action of some form. However, without a significant base of knowledge to accompany these emotive dispositions, it is uncertain if these actions are likely to constitute effective attempts at amelioration.

From the case of Bob, we see that an emphasis on student engagement, and a student-centred, creativity-driven and problem-solving pedagogy may not guarantee the effective acquisition of powerful knowledges. While these approaches can be excellent means to facilitate students' development of favoured dispositions towards learning and the environment, the disconnected nature of STSE knowledge expectations means that the progressive/liberal competence model used for these purposes do not lead to significant gains in scientific knowledge. The interdisciplinary nature of an effective STSE approach that deals with sociological and scientific knowledge with a sufficient level of depth demands of teachers high levels of knowledge and understanding of current issues, which can be challenging for many teachers.

Finally, in Clara's case, we see the performance model of curriculum recontextualizing in use within the context of a highly academically demanding grade 11 university track chemistry course. Here, relatively stronger classification of knowledge types and framing of the classroom discourse means that STSE lessons expectations are clearly signposted by obvious changes in discourse and activity structures. Again, because the official curriculum delimits the STSE learning gains to that which is primarily dispositional and ethico-moral in nature, the disconnect between STSE and scientific content knowledge is obvious and signals to learners uninterested in non-scientific domain knowledge that reduced attention was needed.

Through the three cases, we see the outcomes of interactions between the ORF and the PRF: with a liberal/progressive ORF promoting a pro-environmental agenda and a PRF privileging the performance model of recontextualization, more commonly associated with 'industrial' modes of schooling, it is not surprising to observe strongly classified, discrete, disconnected segments of pedagogy where STSE expectations are dealt with as efficiently as possible. In contrast, in competence

models, a key feature is the weak classification between the scientific content and the STSE knowledge expectations.

## 2. Limitations

The first and largest limitation of this study arises out of the fact that the data collection was initially informed by an earlier theoretical framework which was eventually rejected. While a form of 'reverse engineering' to make data collected compatible to an alternative framework is not always optimum, the degree of difference between the two theoretical frameworks has not been too radical; the major difference being the revised framework's analytical stance. In the revised framework, there is a clearer linkage between the microscopic empirical phenomena with the macro-level sociological theory that this project engages with. One way that this problem has been addressed has been with the inclusion of the curriculum analysis segment of this project. Not present in the initial research design, the curriculum analysis was generated as an organic outgrowth of the revised framework, and subsequently, the case studies were interpreted as the practical outcomes of the affordances and limitations of the curriculum document, among other things.

Beyond these foundational concerns, the research methods have been a compromise borne out of the circumstances of the specifics of this research project—specifically, the curriculum and pedagogy coding instruments have sacrificed a certain degree of accuracy for the sake of efficient processing of a fairly large amount of data. Metaphorically, it is as if a weighing scale has been designed to measure the weight of cattle, but only provides two measurement values, 'overweight' and 'underweight'—surely this instrument must be judged inadequate for comparing between two individual head of cattle. On the other hand, if one were to be interested in comparing the differences between two large ranches, such an instrument, while not ideal, is probably adequate as a

first-pass attempt at characterization. For the classroom pedagogy coding, the coarseness of the unit of analysis has meant that subtle nuances in teacher talk, and variations in semantic range within the lesson phase have been lost. There were definitely discourse segments within a phase structure of a lecture, for example, where teachers made continuous variation to the semantic range of the discourse. Here, there is an acknowledgement that there are significant research traditions that facilitate "thinking about linguistics in sociological terms and sociology in linguistic terms" (Bernstein, 1995, in Martin, 2011), that have not been utilized. The methods of systemic functional linguistics (SFL) appear to be powerful means of producing highly warranted claims in analyzing discourse forms. However, for the purposes of this study, a microanalytic approach typical of SFL techniques may not have been supportive of an expedient parsing of a large body of data, even though it is conceded that the depth of an SFL analysis would be highly desirable.

Because of the use of a case study approach, this study presents generalizable findings only to the extent that the three teachers are representative of certain classes of attributes and contexts that are found in typical teaching situations. To that extent, I have attempted to paint as realistic a description of these attributes and contexts so as readers may judge the degree of verisimilitude that the cases represent. However, these cases certainly do not represent the entire spectrum of teaching contexts available in whatever could be termed as the 'typical' setting for schools in Ontario, or for that matter, Canada or the world in general (certainly, the ambition here is not *that* big). For example, Alice and Clara had students which were academically motivated, very respectful and cooperative. How much success these lessons may have in classrooms with less academically successful students has not been studied. Additionally, all three participants in this study had significant scientific training, were highly experienced teachers who were motivated towards

the implementation of STSE learning objectives, and were successful in their careers. If popular perceptions are correct, there exists a large body of elementary teachers whose training in science terminated at the end of their own high school experiences, for whom scientific ideas are half-retained, along with a (un)healthy dose of scientific misunderstanding[33]. How these teachers deal with the scientific knowledge underlying the STSE expectations is certainly a worthy topic for another study. The point here however, is that the cases represent particular contexts, and while these are fairly common contexts, the utility of these contexts is not necessarily in their representativeness or typicality, but for their contribution to the theoretical problem situation posed here in this study.

Student perspectives were not considered in this study; neither was there analysis of student work produced. While this study is concerned mainly with the pedagogical implications of particular configurations of the curriculum document, a case could be made that student perspectives on STSE/environmental education constitute a more valuable end-result that deserves greater attention—it is, after all, student attitudes and knowledge about STSE/environmental issues which all these efforts are directed towards.

While the curriculum documents and the classroom pedagogy appear to related in that the disconnected nature of the STSE expectations from the scientific content reflects the disconnected pedagogical strategies in the classroom, there is scant evidence collected to warrant a finding of causation. Evidence of this nature could come from something as direct as teacher perspectives obtained through interviews.

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33. for example, I have witnessed a grade five teacher point to the liquid crystal display (LCD) of a digital stopwatch whose numbers were changing and confidently told his students: "See, that's movement energy".

### 3.      Questions posed during this study

Two main issues emerge from this study, both subsidiary to what may be the quintessential question of schooling: What should be the purposes of schooling? Through this study, there is a sense that we have gotten, if not closer to an answer, at least a better understanding of the geography of the current thought on these questions. Although we can surely agree that a desirable response to the question is that schools need to transmit *both* valued dispositions, *and* essential disciplinary knowledge, the exact balance remains a point of contention. Such disagreement is likely for the better, and certainly to be favoured over an unthinking acceptance of one position over the other. Through this study, we come to reflect upon the nature of disciplinary knowledge, and the interactions between valued dispositions and learner identities. The next two subsections will deal with these issues in detail.

*9.3.1      Why study the Krebs cycle: Why is knowledge so important?*

We return now to respond to an earlier point that several researchers have expressed—that (scientific) knowledge is of minor importance in comparison to the uses that these knowledges are put to, and more importantly, that more attention ought to be paid to directly correcting social injustices through the institutions of schooling. The question for this subsection was posed one day in a discussion with several colleagues—"Why teach/study the Krebs cycle? It has absolutely no use in my life, and I'm sure, in the lives of many other people for whom learning it was for the instrumental reason of passing the examinations, and I've since forgotten all about it". Instinctively, a response to this utilitarian assertion had been to pose the response as a *reductio ad absurdum*—that there becomes a slippery slope if one takes up this argument to its logical conclusion—why learn anything *at all?* Most certainly, this is hardly an acceptable defence for the primacy of knowledge,

as it abandons the possibility for neutral ground. But this question struck me as particularly vexing as I realized for myself, in all my years of dealing with science, that I have never learnt what the Krebs cycle was about (even though I vaguely knew it was concerned with cellular biochemistry), and that absence of such knowledge was hardly missed.

To be sure, there is an aspect of which that the utilitarian question posed is a non-starter—the Krebs cycle is introduced only at advanced levels of high school, is certainly not made compulsory knowledge for all and sundry at early grade school; a person who was in such an advanced program would rightly be expected to be in preparation for a future career where knowledge of the Krebs cycle would be helpful, if not essential. But the point raised by the question still stands—why, for example, should we lament the loss of heat capacity as a concept to be taught to grade 7 students? Or why should it be a fuss that the concept of taxonomical classification is removed from grade 4 classes? Surely, as the utilitarian argument would go, one would be able to 'google it' when or even if such knowledge is ever required. Extending the argument, given that there is much harm that schools are complicit in, surely the ethical position is to reduce harm by taking concrete steps to alleviate such harm, and forego 'abstract', 'theoretical' knowledge?

Surely, a seductive argument, but while sadly there is no linchpin to pull to derail the argument, I think it should be sufficient to be able to point out that there should be other considerations for curriculum decisions, especially since the position I am arguing for is not so much a dichotomous either/or, but a more peaceable middle ground. Fundamentally, I believe the utilitarian argument falls down on considerations of scale—that what may be good or useful for societies may not necessarily be good for some individuals. For the most part, life in 'developed' countries has reached such a level of material comfort that we seldom think about what have

become the necessities of life—even the simple matter of turning on the light switch that we have taken for granted is dependent on an entire series of processes and diverse knowledge and expertise, every single step of which presents a possible point of failure. Put in another way, if one were to be suddenly transported into the early Middle Ages, it would be fairly safe to say that not many individuals would be able to recreate an equivalent level of technological innovation. While it is common knowledge that a source of energy is used to make a generator produce electricity which is then conducted via cables into a filament enclosed in a low pressure inert gas filled glass bulb, technological problems, reflecting a lack of scientific knowledge abound—how does one: (i) find sources of energy, like coal? (ii) make a generator—what are the metallurgical properties and processes required to refine and shape the different metallic components that typically make up such a generator? (iii) insulate electrical wires? (iv) get a heat source hot enough to melt glass (v) acquire inert gas from? (vi) seal an electrical filament within the glass bulb? The list, of course, stretches more than these rudimentary questions.

Of course, one could argue that we are no longer in the Middle Ages, and that, barring a freak occurrence like a cataclysmic disaster better reserved for the genres of dystopian science fiction, there is little to no risk that individuals, organizations, and infrastructure will not be in place to carry on our current state of scientific and technological sophistication. However, the problems that we face today are no longer of the mundane challenge of finding a way to illuminate our nocturnal activities—for starters, we are now challenged with a bourgeoning global population, and short of a callous disregard for human life, a way must be found to feed, house, educate, occupy productively, entertain, and generally coexist at universally equitable levels. Certainly, it would be

the height of disingenuousness to claim out of hand that technology *will* have nothing better to offer than 'ecocide' as some more trenchant 'environmental' publications will persuade us?

In searching for solutions to this and other problems, one of the underlying principles surely should be that of "wide base, tall peak"—that in order to have a tall enough peak, one needs to have a wide enough base. Similar to the situation with the light bulb being dependent on a diverse range of processes and technologies which have been widely diffused to the point where we take these products for granted, there needs to be a wide enough base of distributed knowledge, such that an effective solution may emerge. In some way, the situation may be compared to the invention of the light bulb—while Edison is credited with its invention, surely the bulb was a product of its time, and owed much to the scientific and technological advances in chemistry, metallurgy, electrical theory, even the printing press, for distributing information.

So, we return to the crux of the problem—that knowledge is important because education here is perceived to be the pursuit of a better life, for all, and that while we should know and understand the dire situations that our fellow human beings are often put through, knowledge about others' suffering with no real way to alleviate it, is at best, a form of voyeurism. As individuals, we may not *all* need to know the details of the Krebs cycle, but collectively, if we do not have enough individuals who do know about it, how can we intelligently adjudicate between rival policy decisions especially since we are in the era of 'big science', and so many of our social, legal, and ethical precedents are being challenged by science and technology[34]?

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34. I suppose one possible response to this encroachment has been the recourse to religious fundamentalism—if an authoritative text claims absolute dominance over the Truth, why not just submit, instead of taking the intellectually more difficult task of thinking for oneself?

With environmental issues especially, it certainly is the case that "a little knowledge is a dangerous thing"—for instance, with the advent of highly energy efficient compact fluorescent light bulbs (CFLs), much of North America has been enamoured with this advance in lighting technology, some states even considering outlawing the older incandescent bulbs. Upon examination however, the effects of CFL use may not be an unequivocally positive: CFLs, being efficient, produce less heat than incandescents for the same amount of light output. For communities whose electrical supply is generated by emissions-free technology (e.g. nuclear, hydroelectric, geothermal), and whose heat is produced by burning oil, CFL use actually contributes to a net increase in emissions. Certainly, one would agree that an unthinking acceptance of panaceas (technological or otherwise) would hardly be an acceptable means to a solution of the environmental crisis that confronts us. At the very least, it should be agreeable that knowledge about the underlying mechanisms of environmental phenomena form the necessary condition for an intelligent, rational discussion of means to resolution.

In early March 2012, a thirty minute long video was released that quickly 'went viral' on internet video hosting sites YouTube and Vimeo. Told through the story of an American father and his son, it relates the horrors and tragedies purportedly happening to young African children in Uganda, perpetrated by Christian inspired Joseph Kony and his Lord's Resistance Army. Set to brilliant editing and a manipulative soundtrack, the video showed suffering African children exposed to the horrors of war, likened Kony to Adolf Hitler several times, urged its viewers to contact their elected representatives to support a militarized position in Uganda so as to "take down" Kony, and by the way, to support the cause by buying some bracelets to spread the word. The 'Kony 2012' movement was a product of the Invisible Children fundraising organization, and with-

in ten days, the video had garnered over 79 million views, and has been the subject of several special investigations by numerous news sources. Although there was a huge amount of sympathy with the cause, it was also equally quickly revealed that there were significant reasons to believe that the Kony 2012 movement was mistaken, if not an outright fraudulent effort to manipulate public opinion (Branch, 2012). Kony has not been in Uganda for the last six years (Keating, 2012), and Invisible Children has a poor financial rating for not allowing external audits of its fundraising monies. A Yale professor of international development surmises:

> There's also something inherently misleading, naïve, maybe even dangerous, about the idea of rescuing children or the saving of Africa. It's often not an accidental choice of words, even if it's unwitting. It hints uncomfortably of the White Man's Burden. Worse, sometimes it does more than hint. The savior attitude is pervasive in advocacy, and it inevitably shapes programming. Usually misconceived programming. The saving attitude pervades too many aid failures, not to mention military interventions. The list is long. One consequence, whether it's IC [Invisible Children] or Save Darfur, is a lot of dangerously ill-prepared young people embarking on missions to save the children of this or that war zone. At best it's hubris and egocentric. More often, though, it leads to bad programs, misallocated resources, or ill-conceived military adventures. (Blattman, 2012)

While the veracity of the different claims involved in this controversy are not the main issue here, a propaganda campaign like Kony 2012 underscores the importance of knowledge and critical analytic skills which are developed through the process of learning knowledges like science, where rational and defensible decision making are core pillars of the scientific approach. Without justified true knowledge, and the skills to discern for themselves the veracity of truth claims, individuals are likely to fall prey to propagandistic movements like Kony 2012, to negative repercussions all around.

*9.3.2*        *What you know versus who you are?*

More closely to the point of this study, a somewhat more classically sociological analysis of the curriculum compels us to consider the effects of the differential distribution of knowledges in the context of the social organization—in a manner somewhat in opposition to the social realist positions held by many of the researchers reviewed. Taking on the mantle of the muck-raking forms of journalistic 'research' decried by Young (2008a), we could ask the question: if removing scientific content knowledge and weakening the status of abstract theoretical knowledge in science has negative social consequences, who benefits from such changes to the science and technology curriculum? To this end, what follows here is highly speculative and only tenuously related to the empirical evidence collected and analyzed here, but nonetheless discussed as they offer an interesting thought experiment and a possible avenue for future research.

In the last chapter, Clara spoke about the different attitudes towards knowledge and schooling among the various immigrant cultures. Toronto, containing 8% of Canada's population and Ontario's capital city, has a burgeoning immigrant population: 50% of its population being born outside Canada, half of these immigrants having been in Canada for less than 15 years, 12% of the city being South Asian in descent, and 11.4% Chinese (City of Toronto, 2012). Of these immigrants, many of them hold different attitudes to education, some perspective of which could be potentially antagonistic to the North American norms as this quote from a special issue of the Journal of Curriculum Studies on Chinese Education illustrates:

> Paradoxically, memorization and the respect for authorities such as the classics may be a better way to teach students to think critically and creatively than the common practice of critical and creative thinking in the West (in the US in particular): what the latter actually encourages is students' venting their received opinions or frivolous ideas while mastering a classic may help students to transcend their narcissism and myopia

and to have something worth rebelling against. Although joy in learning should be nourished as much as possible, hard work is inevitable. (Bai, 2011, p. 620)[35]

To what extent could these curriculum revisions be a response to the immigrant influx? If, according to Bernstein (1999) any educational reform can be regarded as "the outcome of the struggle to project and institutionalize particular identities" (in Bourne, 2008), what sorts of identities are being projected and institutionalized, and how compatible are these identities to the cultural identities of these migrant learners? Here, the underlying assumption is that immigration is unlikely to be universally welcome by all members of the host culture; and while public policy is one of open-armed acceptance and welcome, there is always the pedagogical task of schooling the 'barbarians' into the local practices, cultures and way of seeing things. Despite progressive claims to the contrary, one of the aims of school systems is to create a hierarchy of individuals, either by knowledge possessed, as in the case of scientific-technical knowledge; or by dispositions held by individuals, as in a certain taste in music or art. If immigrants arrive with dramatically different attitudes towards education, and appear to be outpacing the local host cultures in acquiring knowledge and succeeding in knowledge-related professions (e.g. engineering, computer sciences), would it not be a plausible response to increase the selectivity of the pedagogical device by introducing a dispositional aspect to school knowledge that one acquires through largely invisible forms? In this case, one is not deemed a sufficiently 'educated' person if one, besides knowledge, does not also possess a certain attitude and disposition towards the natural environment.

At this point, I should pause and disclaim any conspiratorial overtones to this line of reasoning, and point out that a similar analysis has been conducted, for higher education in the UK in

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35.  this paper was entitled, provocatively enough *Against democratic education.*

the late-1960s (Maton, 2004). Certainly, a major difference lies in the entirely speculative nature of argument here, but there is at least good precedent established in Maton's study—in the 1960s, there was the challenge of accommodating huge numbers of the post-war baby boom generation who were entering institutions of higher learning; Maton documented and analyzed the discourses and practices surrounding these processes, which ultimately conserved the established hierarchies of the various fields.

Seen in this light, perhaps pedagogical practices similar to those observed in the classrooms of Alice and Bob should not be perceived as deficient in transmitting knowledge, but rather as (effective?) means of transmitting valued dispositions required to be valued individuals, legitimate citizens, and included members of society. Here, again, there is an acknowledgement that the analytical tools presented in this study are underprepared for such a task, and that what is required may be provided by another dimension of the multifaceted evaluative potential of Legitimation Code Theory. As a brief detour, the LCT dimension of specialization (Maton, 2000a; Maton, 2007) can capture and describe the underlying structuring principles that relate to the differential valuing of knowledge and knowers. Maton claims that educational knowledge possesses "two (co-existing but analytically distinct) sets of relations, highlighting that knowledge claims are simultaneously claims to knowledge of the world and by authors" (2000a, p. 154). These relations are termed epistemic and social relations, and refer (respectively) to the relations between the knowledge and the object of study, and between knowledge and the author or subject. These relations can be strongly or weakly classified and framed, and different combinations of strong/weak and epistemic/social relations give rise to different observable modalities. Pertinent to this discussion, we can identify two codes, or modalities of legitimacy: the knowledge code, where epistemic relations are strongly clas-

sified and framed, and social relations are weakly classified and framed; and the knower code: epistemic relations are weakly classified and framed, and social relations are strongly classified and framed; diagrammatically:
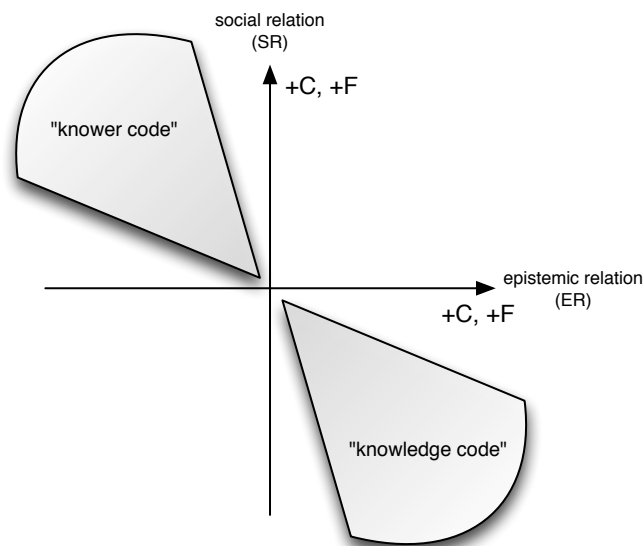


Figure 9.1: LCT-specialization: epistemic and social relations, and two possible modalities/ coding orientations. Adapted from Maton (2007)

The key point to make here is that stronger epistemic relations (+C, +F) of the knowledge code are accompanied by weaker social relations (–C,–F). In other words, even though a school subject like science has stronger epistemic relations, as seen by the strong boundaries between scientific and non-scientific knowledge (+C), and the clearly delineated methods of its practice (+F), scientific knowledge does not strongly classify or frame its social relations to knowledge—one need not be a special kind of person in order acquire the practices and knowledges of science. Conversely, a knower code school knowledge, say, civics and moral education, has weaker epistemic relation—the

boundaries which constitute its knowledge base are tenuous (–C), and there are different, fairly equivalent, avenues for the pursuance of such pedagogy (–F). On the other hand, since the social relations for the knower code are strongly classified and framed, the *kind* of legitimate knower is tightly controlled, and *what* one knows becomes less important than *who* one is, or is to become, in relation to the knowledge.[36]

Returning to the issue at hand, it becomes clearer now that how schools deal with potential code clashes becomes an area of concern—if students arrive with coding orientations biased towards knowledge codes (e.g. the migrant students from East Asian cultures), but are presented with pedagogy that privileges the knower code (e.g., Alice's or Bob's classroom), a code clash is likely to result in student stress and underachievement—exactly some of the findings of a study on Chinese international students' experiences with online learning in Australia (Chen et al., 2010)[37]. Again, no attempt is made here at locating conspiratorial intent—in the context of this study, and generally for that matter, developing knower code dispositions in learners can be essential for individuals to become integrated with the host cultures too.

To summarize this section, while this study was initially interested with the semantic content, the research contexts reveal a possible future direction to continue the research trajectory. While this study has managed to gather some insight into the character of knowledge in use in science

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36.  it is interesting to note here the other modalities made visible by the specialization plane—SR+, ER+ (top right) corresponds to 'elite' code (e.g., school music, theology, architecture—where the source of legitimacy is rooted in both technical knowledge *and* subjective aesthetic appreciation), and SR–, ER– (bottom left) corresponds to relativist code—"where legitimate identity and insight is ostensibly determined by neither knowledge nor dispositions—thoroughgoing relativism" (Maton, 2007).

37.  It is interesting at this point to consider the logical consequences of respecting the wishes of our students—as some researchers appear to be implying—what if they actually *want* didactic, strongly classified knowledge practices? Would it be ethical to insist that they acquire a certain preferred implicit disposition toward the political application of the knowledge instead?

classrooms influenced by environmental/STSE learning objectives, there remain unanswered questions, among others: (i) what are the characteristics of the environmental/STSE knowledge base? While this study has shown that environmental education/STSE stands distinct from scientific content knowledge, a proper characterization has not been done—if scientific knowledge creates a hierarchy of knowledge, does STSE/environmental knowledge create a hierarchy of knowers? (ii) What are students' orientations towards STSE/environmental education? (iii) What are optimum pedagogical strategies to cope with STSE/environmental education in the science classroom? (iv) What are ways in which positive social change may be effected through the pursuance of high quality science education? (v) What is the potential for deskilling for school teachers when disciplinary knowledges are removed and substituted with generic knowledges and dispositions? (vi) Through this study, there appears to be some correlation between curriculum changes and certain manifestations of classroom pedagogy. How much correspondence is there between certain curriculum configurations and particular pedagogies? Can causational effects be shown?

## 4.       Implications for curriculum studies and teacher development

What may be some implications of this study for curriculum studies and teacher development? A big determinant of the validity of these recommendations lies in the reader's degree of acceptance of the epistemological foundations of this project. While I have tried to make a persuasive case for the primacy of knowledge and the significance of knowledge structures for the determination of curriculum, there exist other competitive epistemologies and curriculum justifications, some of which may provide similarly valid and internally consistent recommendations. Hence, caveat in place, I believe the following recommendations to be justifiable: first and foremost, there are significant reasons to at least re-examine ostensibly social ameliorative curriculum

proposals for its underlying epistemological foundations. It should be clear from the earlier chapters that arguments founded on the discourse of voice should be deemed to have little (if any) legitimacy epistemologically, regardless of the ethical position being defended. Arguments which *a priori* privilege the perspective of groups, however oppressed, should at least be deemed epistemologically suspect. This is not to say that the suffering of oppressed groups do not deserve our attention, but rather that any claim to truth that asserts epistemological superiority simply because one speaks for or on behalf of such groups detracts from logically consistent means of argumentation, and demeans positions in support of these groups. Changing curriculum to accommodate the needs of groups simply on the basis of their past oppression is open invitation for all and sundry to make interested proposals; if we admit gendered curricula, we must logically also allow religious, ethnic, and other special interests, regardless of how acceptable they may be to society at large; in no time, the fragmented curricula projects will begin to erode the democratic project of a unified learning experience for members of the nation-state. To make matters worse, if special interests trump knowledge considerations in making curriculum, students will be, to put mildly, misinformed: for example, if religious groups claim that their 'religious feelings' are 'offended' by the teaching of biological evolution in schools, a result of 'religious oppression' by 'dominant' secular groups[38], should we as curriculum scholars necessarily relent and prescribe their acceptable mythology instead? To be certain, there has been an extensive history of well intentioned curriculum projects to 'educate' 'misinformed' native populations; here, while these misadventures are acknowledged, I nonetheless believe that the way forward should involve a meaningful melding of positions, not an aversion to *education* because of past injury. To summarize, it has been my con-

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38.   The excessive use of 'scare quotes' here is deliberate.

tention throughout this project that there be principled means for curriculum selection; that political interests, however ethical and socially ameliorative, should not become the sole over-riding framework for curriculum.

As for teacher development, this research has demonstrated the importance of deliberate semantic variation as a means to achieve the cumulative modality of knowledge production. The progressive action of deliberately alternating between lower and higher semantic range discourse elements is certainly not revolutionary—experienced teachers know the importance of varying content between abstract and theoretical knowledge in the classroom. However, LCT has now provided us with improved descriptivity in the form of the two terms: semantic gravity and semantic density, which may now be used to independently describe two distinct dimensions of discourse variation. For novice and trainee teachers, understanding that good pedagogy arises as a result of the interplay of two basic variables should certainly reduce the challenge of learning to teach. Even for experienced teachers, LCT provides useful language to describe patterns of pedagogy already internalized, so that professional development may be improved.

## 5.    Conclusion

At the end, it is probably worth restating one last time the motivation of the project: this study has been concerned about the effectiveness of school science as a vehicle for social change, especially given the dire environmental and socio-political circumstances that we find ourselves in. Considering the current efforts in science education, it appears that a rethink may be in order. Here, it may be useful to be reminded of an old tale, told by a pseudonymous J. Abner Peddiwell (Peddiwell, 1939). Framed in the Ice Age, the people in a local tribe had become successful teaching their children the skills of Ice Age survival—fishgrabbing, horseclubbing, and saber-tooth tiger

scaring. Now that the Ice Age had ended and the ice receded, rivers had become murky, making fish grabbing unfeasible; the horses' range had greatly expanded and thus were not easy to club; and the saber tooth tiger had become extinct. Fed up with the apparent lack of relevance of the Ice Age school curriculum to the modern post-Ice Age era, several reformers had gathered the village for a curriculum meeting. After the reformers' arguments were presented, it was the turn of the wise old men of the village:

> "Don't be foolish," said the wise old men, smiling most kindly smiles. "We don't teach fishgrabbing to grab fish; we teach it to develop a generalized agility which can never be developed by mere training. We don't teach horseclubbing to club horses; we teach it to develop a generalized strength in the learner which he can never get from so prosaic and specialized a thing as antelope-snare-setting. We don't teach tigerscaring to scare tigers; we teach it for the purpose of giving that noble courage which carries over into all the affairs of life and which can never come from so base an activity as bearkilling. [...T]he essence of true education is timelessness. It is something that endures through changing conditions like a solid rock standing squarely and firmly in the middle of a raging torrent."

While environmental issues appear to be our own post-Ice Age challenge, and a very real one at that, there is a certain sense an applicability of the words of the 'wise old men' to our context, just as it had when the author penned these words in the midst of an intense debate on curriculum in the United States during the 1930s. While science can and may have been taught in absolutely soul crushing and didactic means with no useful relation to the world, there is no necessity for this to be the case. An excellent pedagogy can communicate the excitement of understanding, of control over the natural world (in as non-exploitative sense as that term is capable of), and can certainly bring attention to the environment even if the curriculum documents do not explicitly lay out environmental objectives for learners. As curriculum designers, surely it would be more appropriate for a curriculum document to specify a wider latitude of possible action, rather than to prescribe particular courses of action, however well-intentioned they may be?

# Appendix A—Approval from University of Toronto Office of Research Ethics

## University of Toronto
### Office of the Vice-President, Research

Office of Research Ethics

PROTOCOL REFERENCE # 24672

August 13, 2012

| | |
|---|---|
| Prof. Erminia Pedretti | Mr. Michael Tan |
| Dep't of Curriculum, Teaching and Learning | Dep't of Curriculum, Teaching and Learning |
| OISE/University of Toronto | OISE/University of Toronto |
| 252 Bloor St. West | 252 Bloor St. West |
| Toronto, ON M5S 1V6 | Toronto, ON M5S 1V6 |

Dear Prof. Pedretti and Mr. Tan:

Re:     Your research protocol entitled "Negotiating the complexities of environmental education in the science classroom"

A member of the Social Sciences, Humanities & Education Research Ethics Board has reviewed this protocol under the REB's delegated review process.  Review comments are enclosed for your information and response.

Please address review comments point by point in a cover letter and attach the revised protocol and/or supporting documents to your response.  Additions/revisions to the original protocol and supporting documents should be **bolded**.

Please submit your revisions by email to ethics.review@utoronto.ca within 60 days of this letter. Make sure to include protocol reference number and PI name in the subject line (e.g., **Revisions to #12345, Jane Doe**) Alternatively, you can fax the revisions to  416 946-5763.

Yours sincerely,

Daniel Gyewu
Research Ethics Coordinator

**Review Comments**

**Recruitment Methods (15)**
Please describe this pool of potential participants. In the previous study did you (please indicate the protocol number and title) did you inform them that you were going to keep their names and ask permission to recontact them to recruit in the future? Did you indicate that you would keep there names, or, did you undertake to maintain confidentiality by destroying the list of names? You see what I'm getting at here? Do you have the right to recontact? Please comment.

**Consent by an Authorized Party (20**
Even though you're going to get ethics approval from the school board, do you also need permission from the principal of the school to conduct research in the school? In which case you would need some kind of information/consent letter for the principal(s). Please comment.

**Missing Documents and Other Issues**
Typically, when researchers are going to observe teachers in the classroom we suggest that a courtesy letter go home to parents explaining that you will be observing the teacher for your research, with the relevant details about the study, just to let them know why you are there. Please comment.

The consent doc needs to have contact info for the U of T ethics office.

# Appendix B—School board consent to conduct research

November 27, 2009

Dear Michael Tan,

*Re: Negotiating the Complexities of Environmentalism in the Science Classroom*

The External Research Review Committee (ERRC) of the ▮▮▮▮▮▮▮ School Board considered the above-mentioned proposal at its meeting on November 19 , 2009 and while there was a conditional agreement to approve, a final decision is being deferred until certain items have been addressed.

For example:

- Final OISE REB approval is pending.

- The invitation and selection process for the three case study teachers needs to be clarified (e.g. Are they being recruited from and as an extension of Professor Pedretti's 2008-09 PLC study? Are the ▮▮▮▮ Eco-Schools staff then also aware of and supportive of this study?)

- There are numerous data collection components for participating teachers in both the design and implementation phases of the study over a period of up to five months. These research expectations and time commitments need to be clearly delineated in advance for potential volunteers (e.g. perhaps in tabular form?). This may be included in the "full disclosure information package" however a copy of that document was not included with your materials.

- In the first paragraph of the Principal Information & Invitation Letter, please omit the word "release" (of your teachers), and replace with "participation" perhaps… as this implies that participants are to be excused from class and released from their regular teaching duties.

- Given that there will be ongoing classroom visits for observation, valid Police Check documentation will be expected for the researcher as a frequent school visitor. A copy of that would be required for your file.

- Although students are not direct research subjects, parents shall be informed in writing (explicit consent is not required) about the study and researcher contact information, the rationale for the study, the amount of time spent in the classroom to observe and audio-tape teacher practice, etc.

Upon receipt of the required documents, satisfactory responses to the above issues, and any corresponding revisions or additions to information letters, an updated and final ERRC decision letter could be forwarded. We will look forward to your reply.

Sincerely,

[2009-2010-24]

# Appendix C—Teacher Consent Forms

**OISE**UT  ONTARIO INSTITUTE FOR STUDIES IN EDUCATION OF THE UNIVERSITY OF TORONTO

I, ▮▮▮▮▮▮▮▮▮ agree to take part in a research project that will explore:

1. teachers' curriculum making and pedagogical strategies with regard to environmental education in the science classroom;

2. teachers' underlying beliefs about the teaching and learning of environmental education in the science classroom; and

3. how teachers experience and manage the complexities of environmental education in the science classroom.

The project is entitled:

### Negotiating the complexities of environmental education in the science classroom

Michael Tan, a doctoral candidate at the Ontario Institute for Studies in Education of the University of Toronto, will carry out the research. The following provides information about your participation. If you require any further information or explanation, please contact Michael or his doctoral supervisor Professor Erminia Pedretti. Contact information appears at the end of this document.

I understand that my participation will involve:

a. Three interviews, each lasting approximately one hour, during which I will be asked questions about my experiences, beliefs and practices regarding the teaching and learning of science and environmental education.

b. A series of curriculum planning sessions to design a curriculum unit for implementation. The researcher will offer assistance during these sessions and study the process of curriculum design.

c. Classroom observations by the researcher. These will take place over a period of approximately three and a half months.

d. Please see the information package appended to this document for full details of your expected involvement.

I understand that as a participant:

• I have the right to decline answering any question that is posed during this study;

• interviews and classroom observations will be audio recorded and then transcribed;

• transcripts of the interviews will be shown to me, upon request, so that I can verify accuracy of the transcription;

• that I will receive a copy of the summary of findings from the study and may, if I wish, access the study once it is published; and

• that I can withdraw from the study at any time by indicating so to the researcher.

**OISE UT**     ONTARIO INSTITUTE FOR STUDIES IN EDUCATION OF THE UNIVERSITY OF TORONTO

I understand that all data collected from the study will be kept strictly confidential. There will be no identification of individuals or of their schools and in all cases a pseudonym will be used. The data collected will be used only for the purposes of the research and for presentations or publication for educational purposes.

I understand that by participating in this study I will have the opportunity to explore the challenges of developing science curriculum for environmental education and that there are no anticipated risks for participating in the study. Only the researchers will have access to the data that is collected. All the raw data will be kept in confidence and I will not be identified by name in the study, nor will my school be identified. All the raw data collected during the study will be secured in a locked file and will be destroyed five years after completion of the project.

All interviews and group meetings will occur during the 2009–2010 school year. I have read and understand the conditions under which I will participate in this study and give my consent to be a participant. Also, I have been given a copy of this consent form.

_____         Jan, 29, 2010
Signature                                Date

If you have any questions or concerns about this study, please contact the researcher or the doctoral supervisor.

Researcher: Michael Tan                  Doctoral Supervisor: Professor Erminia Pedretti

Phone Number: 647-869 4188            Phone Number: 416-978 0080

Email: michael.tan@utoronto.ca          email: epedretti@oise.utoronto.ca

Alternatively, you may also contact the University of Toronto Office for Research Ethics:

McMurrich Building, 12 Queen's Park Cres. W, 2nd Floor Toronto, ON M5S 1S8
TEL: 416-946-3273 FAX: 416- 946-5763 EMAIL: ethics.review@utoronto.ca

**OISE UT**

*Participant information disclosure*

This research study is expected to take up to five months to complete. While this project is not expected to make use of this entire period of time intensively, this period is planned as the time for researcher visits, interviews, and active discussion regarding the topics under study. A typical schedule that can be expected is as follows:

| | |
|---|---|
| February | week 1: two hour interview |
| | week 2: classroom observations — 2-3 hours, two hour interview, 2-3 hour curriculum preparation session |
| | week 3: classroom observations — 2-3 hours, 2-3 hour curriculum preparation session |
| | week 4: classroom observations — 2-3 hours, 2-3 hour curriculum preparation session |
| March | week 5: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| | week 6: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| | week 7: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| | week 8: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| April | week 9: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| | week 10: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| | week 11: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| | week 12: classroom observations — 2-3 hours, end-of-week reflection/interview — 1-2 hours |
| May | week 13: optional classroom observations/interview — total 3-5 hours |
| | week 14: optional classroom observations/interview — total 3-5 hours |
| | week 15: optional classroom observations/interview — total 3-5 hours |
| | week 16: optional classroom observations/interview — total 3-5 hours |

Classroom observations are planned to be minimally invasive; the researcher will be seated at the back of the classroom, and will take notes as the lesson progresses. A small audio recorder (about the size of two matchboxes) will be placed in your pocket as you go about your lesson. If you would prefer, the researcher can serve as your aide to assist your lesson implementation.

At the end of the week, as a means to reflect on practice, and as a means to ensure that the researcher has made interpretations of data with which you agree with, the researcher will present you with the field notes and other observations made for the week. During this session, some discussion of the week's events based on these notes will take place, so that your insights may be recorded.

The topic of the interview concerns your beliefs and opinions regarding schooling, education, science, science education, the environment and environmental education broadly. As there are many topics to be covered, it is ex-

**OISE UT**

pected that not all of these questions will be asked during the initial two hour interview, but some questions may be reserved for later curriculum preparation sessions.

During the curriculum preparation sessions, the researcher will work with you to prepare a lesson unit which incorporates environmental education interests into your science teaching. The researcher can be of assistance to provide resources, lesson and activity ideas, and any other support you may need.

As there is a commitment to observe lessons for a fairly significant amount of time so that teacher practice is not misrepresented, the researcher intends to be there for up to two months. However, if both teacher and researcher believe enough data has been collected, this observation period may be shortened. Alternatively, this period may be lengthened in the cases where insufficient data has been collected.

These plans reflect the current planning considerations, and may be modified to suit you. Please do not hesitate to contact the researcher for any clarifications you may have.

**OISE·UT** ONTARIO INSTITUTE FOR STUDIES IN EDUCATION OF THE UNIVERSITY OF TORONTO

I, ▮▮▮▮▮▮▮▮▮▮▮▮ _____ agree to take part in a research project that will explore:

1.  teachers' curriculum making and pedagogical strategies with regard to environmental education in the science classroom;

2.  teachers' underlying beliefs about the teaching and learning of environmental education in the science classroom; and

3.  how teachers experience and manage the complexities of environmental education in the science classroom.

The project is entitled:

**Negotiating the complexities of environmental education in the science classroom**

Michael Tan, a doctoral candidate at the Ontario Institute for Studies in Education of the University of Toronto, will carry out the research. The following provides information about your participation. If you require any further information or explanation, please contact Michael or his doctoral supervisor Professor Erminia Pedretti. Contact information appears at the end of this document.

I understand that my participation will involve:

a.  Three interviews, each lasting approximately one hour, during which I will be asked questions about my experiences, beliefs and practices regarding the teaching and learning of science and environmental education.

b.  A series of curriculum planning sessions to design a curriculum unit for implementation. The researcher will offer assistance during these sessions and study the process of curriculum design.

c.  Classroom observations by the researcher. These will take place over a period of approximately three and a half months.

d.  Please see the information package appended to this document for full details of your expected involvement.

I understand that as a participant:

•  I have the right to decline answering any question that is posed during this study;

•  interviews and classroom observations will be audio recorded and then transcribed;

•  transcripts of the interviews will be shown to me, upon request, so that I can verify accuracy of the transcription;

•  that I will receive a copy of the summary of findings from the study and may, if I wish, access the study once it is published; and

•  that I can withdraw from the study at any time by indicating so to the researcher.

**OISE UT** ONTARIO INSTITUTE FOR STUDIES IN EDUCATION OF THE UNIVERSITY OF TORONTO

I understand that all data collected from the study will be kept strictly confidential. There will be no identification of individuals or of their schools and in all cases a pseudonym will be used. The data collected will be used only for the purposes of the research and for presentations or publication for educational purposes.

I understand that by participating in this study I will have the opportunity to explore the challenges of developing science curriculum for environmental education and that there are no anticipated risks for participating in the study. Only the researchers will have access to the data that is collected. All the raw data will be kept in confidence and I will not be identified by name in the study, nor will my school be identified. All the raw data collected during the study will be secured in a locked file and will be destroyed five years after completion of the project.

All interviews and group meetings will occur during the 2009–2010 school year. I have read and understand the conditions under which I will participate in this study and give my consent to be a participant. Also, I have been given a copy of this consent form.

<div style="height:3em"></div>

████████████                              _Feb. 1, 2010_

Signature                                      Date

If you have any questions or concerns about this study, please contact the researcher or the doctoral supervisor.

Researcher: Michael Tan

Phone Number: 647-869 4188

Email: michael.tan@utoronto.ca

Doctoral Supervisor: Professor Erminia Pedretti

Phone Number: 416-978 0080

email: epedretti@oise.utoronto.ca

Alternatively, you may also contact the University of Toronto Office for Research Ethics:

McMurrich Building, 12 Queen's Park Cres. W, 2nd Floor Toronto, ON M5S 1S8
TEL: 416-946-3273 FAX: 416- 946-5763 EMAIL: ethics.review@utoronto.ca

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c.  Classroom observations by the researcher. These will take place over a period of approximately three and a half months.

d.  Please see the information package appended to this document for full details of your expected involvement.

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- I have the right to decline answering any question that is posed during this study;

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I understand that all data collected from the study will be kept strictly confidential. There will be no identification of individuals or of their schools and in all cases a pseudonym will be used. The data collected will be used only for the purposes of the research and for presentations or publication for educational purposes.

I understand that by participating in this study I will have the opportunity to explore the challenges of developing science curriculum for environmental education and that there are no anticipated risks for participating in the study. Only the researchers will have access to the data that is collected. All the raw data will be kept in confidence and I will not be identified by name in the study, nor will my school be identified. All the raw data collected during the study will be secured in a locked file and will be destroyed five years after completion of the project.

All interviews and group meetings will occur during the 2009–2010 school year. I have read and understand the conditions under which I will participate in this study and give my consent to be a participant. Also, I have been given a copy of this consent form.

████████████████            _February 19, 2010_

Signature                              Date

If you have any questions or concerns about this study, please contact the researcher or the doctoral supervisor.

Researcher: Michael Tan                 Doctoral Supervisor: Professor Erminia Pedretti

Phone Number: 647-869 4188              Phone Number: 416-978 0080

Email: michael.tan@utoronto.ca          email: epedretti@oise.utoronto.ca

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## Appendix D—Grade 7 Heat Activity

Keeping the heat in for better health.

The Homeless Energy Association of Toronto has requested design ideas for helping the homeless make it through the colder parts of the year more comfortably with environmentally sound adjustable outerwear. They have raised a considerable amount of money and want to make sure that it is well spent. Many homeless people get ill much more often than most people because they are unable to adapt to the temperature ranges especially in the fall, spring and winter and therefore use up larger energy stores for keeping warm rather than healthy. Using your knowledge of what you have learned about heat and living things, design an outerwear system that can be used year-round for keeping dry and warm during inclement cold and wet weather by homeless people.

Engineering parameters and constraints:

The outerwear system should be made in such a way that it can be bundled small enough to keep close to oneself in order to be safe from theft when it is not being used. It should also be able to be adjusted to colder temperatures by adding easily available materials to keep in the heat and disposing of these materials when it gets warmer or dirty. Minimization of material use is important because the less material used the more systems can be made. The materials available for your basic outerwear system design are listed. You do not have to use all the available materials.

Materials and tools:

Materials will include plastic sheet, mylar sheet, various sized plastic bags, twine, cotton sheet, thread and "waterproof tape" (all materials will be considered to be fireproof). Other safe and easily accessible materials can be brought as decided and supplied by the group as needed.

Tools will include scissors and needles for creating your prototype.

Your prototype will be tested for its ability to keep in the heat and keep out the rain through a science & technology class designed experiment.

Engineering process:

- θ Everyone will create their own design to be submitted to the teacher.
- θ Teams of three will make and test their system design.
- θ Everyone will individually reflect on their group's design's based on the criteria of keeping the heat in and the wet out as well as the product's other good and bad points.

Design & Test Components:

**Individually: Part 1**

Use your knowledge of heat transfer ideas and materials properties to design the system through words and diagrams. Explain why you chose the materials and way to put them together using heat and energy terms such as conduction, convection, radiation and insulation and the way the human body needs to be kept warm for it to work best.

**Group of 3: Part 2 and 3**

Decide how to combine the components of each member's ideas to make the best possible system. Make the system and test it for heat retention and wetness protection using the class "fair test" experiment.

**Individually: part 4**

Evaluate your groups' design solution based on the ability to keep in the heat, keep dry and amount of material used to make the system. Identify any good and bad points about the design.

**Group of 3: Bonus**

Create a marketing plan or pitch for your design for the H.E.A.T. group (bonus).

<u>Class Designed experiment for fair testing of the homeless heat system designs:</u>
Since you are going to be making a model of a heat control system, you need to able to test its effectiveness, or how well it works. Using your knowledge of heat movement, design a testing protocol that will test how good your solution is compared to the other solutions in the class.

What things are you trying to find out about?
Can they be measured?
        - if so, how are we going to measure them,
        - if not, should we concern ourselves with them?
Why are you trying to measure these things?
How can you measure these things <u>fairly</u> so we can find out what systems worked as designed and how well it worked compared to other designs?

<u>Instructions and ideas for making a good project.</u>
Part 1: individual design process: Use pictures, drawings and words to describe your ideas.
- θ    What heat knowledge does your design use for keeping a person warm and dry?
- θ    What materials are you using, and describe why you are choosing to use them that way?
- θ    What environmental factors about homelessness did you consider in the design?

Part 2: group design and make: Keep track of your group ideas, materials and changes in your plan as you work through your ideas. Keep all your materials in a shoe or similar size box. Think about taking pictures of the process for your bonus presentation.

Part 3: Testing of your group's designed product using the fair test developed by the class.

Part 4: Individual self evaluation and reflection of your group's product and process

Marking Scheme for HEAT project:

| Criteria | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Knowledge about heat transfer Part 1&4 | Uses less than three heat transfers methods to consider person or materials or environment | Uses all three heat transfers methods to consider person or materials or environment | Uses all three heat transfers methods to consider person and materials or environment | Uses all three heat transfers methods to consider person and materials and environment |
| Design meets criteria for success Part 3&4 | System barely keeps the temperature constant and barely keeps it dry | System keeps temperature somewhat constant and keeps it somewhat dry | System keeps temperature mostly constant and keeps it mostly dry | System keeps temperature constant and keeps it very dry |
| Materials are well used and not wasted Part 2&3 | System uses some materials inappropriately | System somewhat uses materials well and some waste is evident | System mostly uses materials well and little waste is evident | System always uses materials well and virtually no waste is evident |
| Communication of ideas through drawings, pictures and words Part 1, 2, 3 & 4 | Design and problem solving notes and evaluation of criteria for success are not particularly well organized, legible or make little sense | Design and problem solving notes and evaluation of criteria for success are somewhat organized, legible and make sense | Design and problem solving notes and evaluation of criteria for success are mostly organized, legible and make sense | Design and problem solving notes and evaluation of criteria for success are well organized, legible and make sense |

## Appendix E—Lysol Task



OOH! DOMESTIC CRISIS!

Sue was furious at Tom for the way he'd been treating her. But she was really to blame! She should have known better, for she was no stranger to feminine hygiene. It was just that she had become neglectful! Her doctor straightened her out. "It's foolish to risk your marriage happiness by being careless about feminine hygiene—even once!" he said. Then he advised her to use Lysol disinfectant for douching—always.

AH! DOMESTC BLISS!

Heavenly is the word for Sue and Tom's home life now! Wise Sue immediately took her doctor's advice, Always, she uses Lysol for douching...knows for herself how thoroughly this proved germ-killer cleanses, yet how gently! Lysol is far more dependable that salt, soda, or other homemade solutions. "What's more," says Sue, "it's easy to use—economical, too!"

Check these facts with your Doctor

Proper feminine hygiene care is important to the happiness and charm of every woman. So douche thoroughly with correct Lysol solution...always! Powerful cleanser—Lysol's great spreading power means it reaches deeply into folds and crevices to search out germs. Proved germ-killer—uniform strength, made under continued laboratory control...far more dependable than homemade solutions. Non-caustic—Lysol douching solution is non-irritating, not harmful to vaginal tissues. Follow easy directions. C???? odor—disappears after use; deodorizes. More women use Lysol for feminine hygiene than any other method. (For FREE feminine hygiene booklet, write Lehn & Fink, 483 Fifth Avenue, New York, N.Y.)

Figure 9.2: Lysol advertisement—Advertisement copy enlarged on the right

There are several 'layers' which you could make your argument at. On one level could be the feminist-sexist critique based on the idealised body images seen in the advertisements which are ultimately demeaning and derogatory to women. On yet another level you could talk about the chemical hazards of using these formulations, some of which may contain rather nasty chemicals, albeit in small amounts.

1. Study the advertisements carefully. Identify at least five claims that are made in the advertisement that you have chosen. (10%)

2. Study the text and the pictures used in the advertisements. Identify at least three assumptions made in the advertisements. These assumptions could be related to: (a) science; (b) the status of doctors; (c) the responsibility for 'feminine hygiene'; (d) germs and health; (e) men and 'feminine hygiene'; (f) the relationship between men and women; (g) any others that you can find.

Provide evidence to support your identification of these assumptions. Pay attention to font, formatting, layout, uses of imagery. You may mark up the advertisements to indicate your findings. (20%)

3. Do you think this advertisement would work today? Why/not? (10%)

4. Do some research on the Internet to find out more information about Lysol. The active ingredient of Lysol is benzalkonium chloride, or alkyl dimethyl benzyl ammonium chloride (ADBAC)

a. List three physical properties of ADBAC. (5%)

b. Describe what LD50 or LC50 is. These are measures of toxicity. (5%)

c. Compare the toxicity of ADBAC to other commonly used antiseptics like ethanol, chlorine bleach, hydrogen peroxide, and iodine, making use of the conventional measure of toxicity, LD50 or LC50. You can also perform searches for toxicity/ pharmacology of ADBAC. (10%)

5. Is the use of Lysol as vaginal douche recommended? Why? Why not? Are there any environmental hazards related to the use of Lysol? (10%)

6. On a separate piece of paper, write a short letter to a friend who is still using Lysol as vaginal douche, discouraging her from the practice. Please use proper letter format, with three paragraphs, in about 400-600 words. The letter should be a persuasive document, contrasting the advertisement claims and the scientific evidence that you have researched, and also discuss the sexist biases that you found (30%)

Figure 9.3: Questions for Lysol Task

## Appendix F—Podcast task

| | |
|---|---|
| **Chemistry and the Environment**<br><br>Now, having studied a vintage advertisement, we can begin to critique something more recent. The general strategy is similar: consider the claims and assumptions made by the advertisements, study the ingredient makeup of the products, then compare and contrast the claims and assumptions with the known properties of the chemical components of the products.<br><br>You have completed a written task where you persuaded a friend about the use of Lysol. At this stage, we want you to extend your reach and convince a larger audience about the personal and environmental effects of the use of chemicals in our daily lives.<br><br>**Your task**<br><br>For this project, you and a partner will design and produce audio podcast of 3-5 minute duration. This podcast should be designed in the style of a Public Service Announcement, where you inform as wide an audience as possible to convince them to take action on an important matter of concern. It should take the form of a standalone segment designed to be aired in a radio current affairs channel like the BBC World Service.<br><br>To make a convincing and attractive message, your podcast should:<br>• be well researched, make sense, and be meaningful<br>• contain typical aesthetic elements that are typical of its format, for example:<br>• opening and closing music<br>• sound effects as appropriate (use them sparingly)<br>• interviews with experts; person-in-the-street perspectives ("Vox populi")<br>• be of topical interest to a contemporary audience<br>• not be overly laden with technical terms that it hinders comprehension. You can assume your audience is fairly well-informed (grade 12 on average), but not necessarily trained in chemistry.<br><br>To help you along with your task, here is a list of possible topics that you could consider: | 1. pollution caused by release of hormonal medications (e.g. birth control pills, endocrine disruptors, pseudo-androgens) in the drinking water and sewage system<br>2. phosphates in detergents causing aquatic pollution<br>3. cleaning products and their impact on the environment<br>4. 'superbugs' – drug and chemical resistance from overuse of drugs and chemicals<br>5. bisphenol-A use in food handling and packaging<br>6. cigarette smoke chemical ingredients, cigarette additives<br>7. CFL use and mercury disposal<br>8. brominated flame retardants (BFRs) in consumer goods<br>9. carcinogens in personal care products<br>10. Crude oil pollution in the US Gulf coast<br><br>**Instructions**<br><br>For this project, you are required to hand in:<br>• an ongoing journal: in this journal you will record your initial research findings, pages searched, reflections on the task, notes and the 'rough workings'. Be as verbose as you can to document your process.<br>• a short (1-2 pages, 300-500 words) research writeup: on this writeup you will summarise your findings about the issue you have chosen. This should include the scientific information, along with other pertinent aspects (e.g. social factors) surrounding this issue.<br>• a podcast script: before you record your podcast, you will plan and have on paper a complete script indicating roughly the timing and the content of your podcast. The timings should be fairly accurate, so do rehearse your script several times before committing these times to paper.<br>• an end-of-project reflection/summary paper (1-2 pages, 300-500 words) recording what you have learnt, your thoughts about the topic you chose |

Figure 9.4: Questions for the podcast task

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