Transforming the technologies and modalities of learning:
The New Life Sciences in secondary schooling: An Introduction.

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Abstract

This paper introduces a range of issues involved in researching classroom activities in the growing curriculum area known as the “New Life Sciences” (NLS). It describes the need to continue and support new ways of learning and using literacy as the school years progress and then outlines the significance of multimodal representations of knowledge in NLS and the foundational use of digital technologies in the growth of this discipline. It gives a brief outline of the nature of NLS developments and concludes with a summary statement of the context for the NLS research project from which the papers following in this symposium are drawn.

Introduction

This project began as an inquiry into literacy education in senior secondary schooling, and the effects of paradigm-level developments on the teaching and learning of curriculum-specific literacy capabilities. It was also motivated initially by concerns that literacy education has often been viewed as a teaching and learning domain that is pretty much done by mid-primary years. It has grown into a larger set of concerns about pedagogy and learning.

In his comprehensive summary of the research on the economic consequences of human skills formation, Nobel Laureate for Economics James Heckman announced a key message for educators: Early learning gains must be maintained by complementary learning experiences, otherwise the original educational investments will be dissipated, yielding close-to-zero returns for the system, the society, and the individual: Complementarity (synergy) of investment reinforces self-productivity … this empirically established complementarity also suggests that early investments must be followed up by later investments to be effective. (2005: 3-4).

In the broadest sense, this project focuses Heckman’s point on literacy across the school years and curriculum areas. It is about the maintenance of literacy learning in an emerging curricular field that puts new technologies and various modalities to work in new ways. The argument connects this with the huge investments made by societies in literacy learning in the early years of schooling and how they can and should be complemented by the persistent development of literacy skills as students encounter the curriculum areas and technologies of the middle and senior school years.

Emerging disciplinary and technological innovations have implications for learning and knowledge formation: Digital technologies have accelerated the empirical exploration and simulation of phenomena that were formerly too small, large, slow or
fast to be easily studied and taught – the chromosome, the cell, the galaxy, evolution, and the rest. They have as well begun to reshape and accelerate the emergence of entire fields of study. This process is perhaps most prominent in the case of the ‘New Life Sciences’ (NLS), a collection of increasingly specialised areas of bioscience such as neuroscience, biochemistry, genetics, evolutionary biology, as well as cellular and molecular biology. The NLS make new connections between these areas and the disciplines of mathematics, physics, chemistry and earth and space sciences. In the NLS much new knowledge can be produced, disseminated, and effectively taught only via digital technologies, and much is represented in symbolic forms other than, or in conjunction with language.

The relationship between the emerging paradigm of NLS and its empirical and educational reliance on digital technologies implicates two issues – those multimodal ways of knowing and representing most readily afforded by ICTs, and the additional affordance of open-ended, extended experimental, exploratory investigations. Theorisations of teaching and learning that draw on cognitive and interactional analyses, and the empirical bases they rest on, do not currently address these issues well. Further, such considerations put pressures on education systems (especially syllabus developers, technical supports, assessment practices, teacher-education programs, schools as well as teachers) to provide students with new kinds of educational experiences. This project aims to respond to these rapid and mutually-reinforcing developments through the design of a research program that is aimed at a better theorisation of and improved practices in senior secondary Science classrooms.

This issue has both quality and equity aspects: Teese and Polesel (2003; and see, e.g., Lamb, 2001) have argued that the maintenance of the social compact between society and government, as embodied in schooling, depends on opportunities for high achievement, and its consequences for pathways of choice, for all students, even those in ‘average classrooms’ in ‘average schools’. Teese and Polesel pointed out that, without an insistence on examining curricular and pedagogic patterns as they occur in the most characteristic settings of the school system (2003: 223), inequalities of educational experience will be unavoidable.

Applied here, the need for new understandings about the relationship between contemporary ICTs, multiple modalities, and NLS as an emerging paradigm, intensifies this concern over provision of educational experiences to a wide range of students, not just those in economically and materially best-resourced sites or those taught by the newest graduates. This project is documenting practices and intervening in classroom settings that are representative of the variety of resources on offer to Australian students, aiming to focus current theoretical and technological best practice in combination with the most promising current classroom activities of the participating teachers.

**Modalities and Technologies**

Language and literacy in the classroom have become a research focus in Science education. Investigations into multimodalities of teaching and learning science (e.g., Kress et al 2001) show that, along with the written and spoken word, communication
modalities at work include gesture, body language, eye contact and movement. Findings indicate that in the Science classroom speaking is not the dominant mode of communication; teachers and students construct knowledge about particular scientific themes, such as cells, as a result of an orchestration of a range of modes...each with specific representational and communicational affordances and provenances that contribute in particular ways to the multimodal ensemble (Jewitt and Scott, 2002).

Even a cursory comparison of ‘old’- (i.e., print-) technology textbooks in use 10 years ago and today sends out a clear message with respect to the use of multiple modalities in the representation of knowledge. When the forms of animation, visual, and auditory representation routinely in use in digital settings are added to that mix, the shortfall in current educational practice, including teacher education, becomes urgent:

We need to understand how narrowly restrictive our literacy education traditions have been in the past in order to see how much more students will need in the future than we are now giving them ... photo images, video clips, sound effects, voice or audio, music, animation, or more specialized representations' (mathematical formulas, graphs and tables, etc). (Lemke, 1998: 288)

In studying the use of multiple semiotic modes in Science and Science education, Lemke (2002; 1998; and see 1990) explained why Science and Science teaching are necessarily multimodal: Different meaning-making resources have different strengths and weaknesses. Important here is the distinction Lemke drew between ‘typological’ and ‘topological’ meaning-making: “[a]ll semiotic resources, whether verbal language, mathematics, or visual representation, combine two basic principles for making meaning: meaning by kind and meaning by degree” Lemke (2002). Each semiotic resource is optimally organized around a certain type of meaning-making:

Language, as a typologically oriented semiotic resource, is unsurpassed as a tool for the formulation of difference and relationship, for the making of categorical distinctions. It is much poorer ... in resources for formulating degree, quantity, gradation, continuous change, continuous co-variation, non-integer ratios, varying proportionality, complex topological relations of relative nearness or connectedness, or nonlinear relationships and dynamical emergence. (Lemke, 1998: 87, 92)

Mathematics, visual representation, and gesture, for example, have evolved chiefly to help people make these latter, topological meanings, but, as Lemke (2002) pointed out, studying and producing scientific knowledge calls for both qualitative / categorial and quantitative reasoning practices (see also Guo, 2003).

These developments are cultural, and, as the conclusions of studies in a number of countries have indicated, teachers need to come to terms with them rapidly, reshaping their understandings and practices, in the main without much theoretical or empirical guidance. With the growth of information in the NLS come questions about which modes of communication best represents what content, and whether changes in the
representation of knowledge amount to changes in knowledge? National school science curricular objectives emphasise the transmission of scientific knowledge and the training of scientific ways of communicating (‘talking and writing like a scientist’), and then changes in the communicational environment will be crucial, most evidently in NLS.

**New Life Science**

A recent report published by the Dolan DNA Centre in the US states that “the growing importance of modern biosciences demands a society of modern biology literates. However, biotechnology is advancing so fast that the gap between research progress and public understanding widens every day.” On discussing ‘new’ biological literacy, Campbell (2004, p98) notes “If students are to be literate in modern biology, then teachers will need to be aware of the impact that new molecular information are having on all areas of biology. Molecular tools have integrated areas within biology previously considered distinct, such as biochemistry, ecology, genetics, and behaviour. With the advent of genomics and its allied fields of proteomics and bioinformatics, integrating information across many subdisciplines of biology is becoming increasingly important for research and teaching. Furthermore, many leaders in genomics, proteomics and bioinformatics (referred to here as genomics) are emphatic about the need to provide free access to data and to electronic research tools. This confluence of needs for information and interdisciplinary learning have led to a unique time in biology education.”

In Australia the federal and state governments have recognised the significance of modern biosciences (biotechnology, genomics, proteomics, bioinformatics) in the curriculum. The National Curriculum outcomes highlight the social consequences of the biological sciences and some teaching of the evaluation of bioethical issues has been included in most state curricula (Dawson, 2001). However, although education in the modern biosciences has gained recognition “less is heard about how to teach effectively in areas that require sensitivities to moral, ethical and social dimensions which are linked to the use of technologies” (Conner, 2000, p.3). Factors inhibiting the successful implementation of modern biosciences in school curriculum include the need for teacher knowledge in the area, limited resource materials and the lack of time to fit in another topic (Wilson, Kirby & Flowers, 2002; Zeller, 1994), the complexity of the abstract concepts (Venville & Treagust, 1998), the call for innovative teaching methods and problems with the controversial nature of the material (Dawson 2001).

Other researchers (e.g., Unsworth, 2001) have set out to explore and improve the classroom practicalities associated with multimodal learning. One of the general conclusions available from current research is that, while multimodal text analysis has advanced significantly over the last fifteen years (see e.g., Emmison & Smith, 2000; Jewitt & Kress, 2003; van Leeuwen & Jewitt, 2001), there is now a need to move from descriptions of the structure and meaning-making potentials of multimodal texts toward a detailed description of how teachers and students do and might use those potentials in everyday educational settings, on to a close study of how it is that new, digitally-reliant disciplines such as NLS, and their curricular manifestations in schools, configure and put to work multimodal textual experiences (Kress, 2003; Lajoie, 2000). In this study, these questions form the focus of attention and act as a
platform for the development of interventions aimed at sharpening these understandings and building the capabilities of teachers and learners.

So the argument is that to appreciate, theoretically and practically, the ways in which literacy can be ‘maintained’ through the school years is to engage its reconfiguration, pedagogically and cognitively, through encounters with i) discipline-specific ways of representing knowledge and ii) the technologies that make those representations possible in the use, transformation and production of knowledge. Digital literacy derives its complexity as a field of practice and study from the practitioner’s need to understand information in multiple formats and the skills of deciphering, among other things, images, sounds and text. (Gilster, 1997; Lanham, 1995; Lynch, 1998).

**Task design**

A further dimension of learning activities and settings in NLS classrooms relates to the degree of structure and ‘definiteness’ of bodies of knowledge and tasks. Here we draw the distinction between Stipulative and Open-textured knowledge and tasks. (In some traditions of research and theory, this is referred to variously, as, for example, ‘well- versus ill-structured’ or ‘open versus closed’ domains.) This distinction has been discussed (by, e.g., Jonassen, 1997) in these terms: Stipulative problems are those that are constrained, with convergent solutions that engage the application of a limited number of rules and principles, and with well-defined parameters, right answers and right ways to them; Open-textured problems entail potentially multiple solutions and solution pathways, fewer set parameters that are less manipulable, and uncertainties about which concepts, rules, sequences, and principles may be necessary for the solution, how these issues may be organized, and which solution is best for the particular task at hand.

Traditionally Science has been regarded as operating with strict, definition-based concepts that have determinate and generally abstract meanings, compared to some other subject areas that tend to operate with more open-textured concepts, in which the key categories, their attributes, and evaluations of their efficacy and moral value are subject to multiple interpretations. Traditional Science can be characterised as presenting students with a set of convergent goals, in which quasi-algorithmic, linear sequences of procedures lead toward a verifiable position (a "right answer"); other subjects and disciplines generally present students, in their school tasks, with a cyclic, non-linear movements of procedures toward a broader base of multiple accounts, leading perhaps to a provisional, bounded position (a ‘warrantable or defensible’ interpretation or point of view). ICTs have been found to play a positive role in fostering the cognitive flexibility required of ill-structured problem-solvers (Spiro, Feltovich, Jacobson, & Coulson, 1992; Wiesenmayer & Koul, 1998) and in enabling the sharing of information and discussion about the factors relating to contextualised problems (Jonassen & Hyug, 2001).

This contrast – between closed versus open-textured information and task domains, or Stipulative versus Open-textured problems – itself interacts with the multi-modal and on-line perspectives available through the engagement of digital technologies. The
sources of knowledge with which students may deal in such an environment are compacted in time and space, available online for immediate multiple access and use.

Saye and Brush's (2002) recommendation of a learning environment whose core foundations and values are consistent psychologically, pedagogically, technologically, culturally, and pragmatically becomes crucial in the NLS, where much of the learning activity is exploratory and experimental (Barab, Young, and Wang, 1999). The issue for educational theorists and researchers concerns the potentially negative consequences, specifically in NLS, of the use of pedagogies that may be well suited to the teaching of other disciplines and epistemologies but that may simply not afford NLS knowledge, as it is embodied in modalities and tasks, and afforded via certain technologies.

Conclusion
The growth of the NLS as a meta-discipline presents a challenge and an opportunity to theorists and researchers interested in teaching and learning, especially those working in literacy education. The task is to incorporate more pervasively the significance of ICTs as sites for learning and for displays of the mastery of knowledge, in multi-modal and open-textured task domains. As Bransford and Schwartz (1999; and see Bransford et al., 2000) have shown, most learning and assessment in schools are predicated on the ‘direct application’ of fixed bodies of propositional knowledge, rather than on ‘preparation for learning’ in variable, open-textured, multi-modal and multi-technological settings. Australian Science Curricula generally endorse a range of teaching and learning settings ranging from inquiry- and problem-based learning along a continuum to rigorous laboratory studies. In some states, authentic scientific experiences are emphasised in the NLS through independent and extended experimental investigations spanning up to a full term of the school year (QSA, 2004). This new emphasis has been matched neither by a growing research base nor by changing teacher professional development, nor has any comparable change become evident in teacher training programs. The significant need is to evaluate, analyse and enhance classroom interactions around the new ICTs and modalities associated with the teaching or supervision of these authentic scientific investigations. Studies such as this one aims to generate and document interventions that help teachers manage the design, analysis and assessment of classroom teaching and laboratory projects in the NLS. It also aims to provide research support for teacher educators to provide in-service and pre-service programs that develop of these skills and understandings.

The project aims at sophisticated theoretical and analytic frameworks for understanding the changing intellectual, technological and communicational parameters of contemporary education. These frameworks need to be accessible enough to become part of the conceptual repertoire of professional practitioners. But they also need to be flexible enough to allow practitioners to maintain currency in evolving fields of knowledge such as NLS. The implications for the labour market and for international competitiveness of the efficacy and currency of Australian Science and ICT education efforts, in the emerging NLS context, call for a systematic program of re-theorisation, collaborative trialling, and intervention. While this project will have direct implications for the secondary and tertiary teaching and learning of a
range of subjects currently being reworked by new ICTs and by increasingly multimodal representation, the argument here is that the urgency is most keenly felt in the NLS.

References and Bibliography


