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The Potential of Adapted Primary Literature (APL) for Learning: A Response

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This set of papers is to be welcomed in that they challenge established notions of what it means to learn science. The basic concept in all of them is that there is something of value to the learning of science to be gained from using adapted primary literature (APL). For the reader, the questions are many. For instance—what contribution to the student understanding of science will the use of adapted primary literature make? Is there sufficient data here to justify the arguments of the authors? What are the theoretical presuppositions on which this body of work rests and are they justified?

Phillips and Norris (2009) begin by pointing to the centrality of reading to the work of the practicing scientist developing the seminal argument they have previously made that literacy is fundamental to science (Norris and Phillips 2003). Using the data drawn from Tenopir and King's study (Tenopir and King 2004), their case for the core nature of communicative activities in science is unequivocal—in particular that it is impossible to conceive of science without reading or writing. In one sense, this is hardly surprising. Longino (1990), for instance, points to the fact that science is a social and communal practice:

> 'What is called scientific knowledge, then, is produced by a community (ultimately the community of all scientific practitioners) and transcend the contributions of any individual or even a subcommunity within a larger community. Once propositions, theses, and hypotheses are developed, what will become scientific knowledge is produced collectively through the clashing and meshing of a variety of points of view.

And it is impossible to envisage such practice without acts of communication be they oral or written. What is surprising, as Phillips and Norris point out, is the common misconception, sustained by school science, that science is a 'hands-on' rather than 'minds-on' activity. Such an emphasis is misplaced because it is the products of our thoughts about the world—that is our theories—not its manipulation which 'are the crown of science, for in them our understanding of the world is expressed' (Harré 1984). Theories are the apotheosis of science because they are the major creative achievement of science—the

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imagined models, analogues or representations of the material world and the product of original thought. Such thoughts are successful to the degree that they provide explanatory and predictive hypotheses of the material world. Manipulating the material world and gathering experimental data is always a secondary or subsidiary scientific activity for 'observation and experiment are not the bedrock upon which science is built; rather they are handmaidens to the rational activity of constituting knowledge claims' (Driver et al. 2000).

The premise of these authors is that offering students learning experiences with APL is one way to educate students both *in science*—in that the activity will replicate the kind of activity engaged in by practicing scientists—and *about science* in that the activity will afford a more authentic representation of the processes of science. Part of the argument rests on an analysis of science textbooks which shows the total dominance of expository text (Penney et al. 2003) and the absence of any argumentative text—a normative feature of primary literature. APL, then, offers a window into the epistemic practices of science. But is this difference surprising?

To answer this question it is useful to turn to an important, if flawed distinction, made by logical positivists between the 'context of discovery' and the 'context of justification' (Reichenbach 1938). In the former, ideas are tentative, if not speculative, and described in language which is interpretative and figurative (Sutton 1996) often using new metaphors (Hesse 1963; Lakoff and Johnson 1980). In the context of justification, from the positivists' perspective, theoretical statements must be logically deducible from observational data. Whilst such a view has been shown to be a historically unsatisfactory account of science, it is true that the focus of the primary literature is on providing a justificatory account for the knowledge claims it seeks to make about the world. Textbooks, in contrast, deal in well-established, consensually-agreed knowledge. Their focus is what might be termed the 'context of reproduction' of such knowledge. Such a context is that of the classroom which offers its students explanatory accounts whose justification if often minimal as its logical coherence is taken as a given. Hence the use of the present tense—'the structure of DNA is a double helix' and the excision of any tentativeness or conditionality in their statements. Given that the dominant focus of most, if not all, science classrooms is on developing an understanding of the basic concepts of science, to expect otherwise would be misguided. After all, the reader of the science textbook seeks an authoritative statement of our contemporary understanding of the material world and is often reliant on such texts for the epistemic justification of their beliefs. Any textbook that began its explanatory account by stating, for instance, that one explanatory account for day and night is offered by the heliocentric view of the world whilst another is offered by the Ptolemaic perspective would simply fail to fulfil its required function, even it were it to explain the criteria by which the heliocentric is judged a better explanatory account. Such an account might be valued by the student interested in the history of science but not by the student who seeks the consensually-agreed explanatory account. Successful textbooks are judged then by the quality and accessibility of the explanatory accounts they offer. Their argument is not reliant on primary data sources (from which they are far removed) but on a multi-modal account of how the world *is*. Their role is not to offer competing explanatory accounts or a chronological unfolding of the route to our current world-view, but rather, a clear and transparent explanation of the contemporary understanding.

The move to using APL then is an attempt to redress this balance and offer students some insight into the context of justification. The papers by both Falk and Yarden (2009) and Norris et al. (2009) argue that they enable both the emergence of authentic scientific practices and learning by inquiry. Indeed Phillips and Norris go further to argue both here and elsewhere (Norris and Phillips 2008) that reading is best thought of as an inquiry process itself. Undoubtedly, both papers provide good evidence that the use of APL does go some way to achieving such goals. Falk and Yarden show how, in a detailed qualitative study, students use of APL texts required them both to construct meaning from the text and to engage in critical discussion of the findings. Their work builds on a program of research (Baram-Tsabari and Yarden 2005) which had established that students who read primary literature developed better inquiry skills than those who read secondary literature. Norris et al.'s study is more exploratory examining the effects of using a piece of web-based APL literature on student understanding. They too conclude that, despite the difficulties, such work does demonstrate that students are capable of a deeper conceptual understanding and, in addition, comprehending the limits of mathematical models in representing the world. Clearly such work has something to offer the learning of science and represents a bold and innovative exploration at engaging students in the process of inquiry and what may seem more authentic practice.

However, such work rests on several assumptions which should at least be questioned. The first is that 'learning to read scientific text leads not only to the possibility of learning the substantive content of science, but also to learning its epistemology'. But, it must be asked, is this the most appropriate manner? Drawing on the work of Halliday and Martin (1993), Norris and Phillips point to the fact that science is a 'cumulative discourse that trades on fixities of text and on what is taken for granted by that text'. The corollary of this feature is that the entry cost for the novice reader becomes higher and higher with each ensuing generation. Part of the popularity of the presentations of what constituted contemporary science in the early 19th Century in the salons of London is explicable by the fact that it was comprehensible to the educated person of the day. In contrast, contemporary science, because of the inherently cumulative nature of science becomes ever further removed from the understanding of the layperson. Adapting primary literature to diminish the background knowledge required to successfully construct an appropriate interpretation of its meaning is one approach but is it the most apt? It could be argued, rather, that the texts that most students will commonly encounter in their future lives are media reports of science and that this type of literature should be the focus of science education.

A second premise, advanced explicitly by Norris and Phillips (Norris and Phillips 2008), is that reading itself should be seen as an act of inquiry. Their view is rooted in the wholly justifiable position that reading is a constructive process and that meaning must be inferred from text by forging inferential links between the reader's background knowledge and the text. None of this is disputed. Even more, it is a view that recognises that the central task of the science educator is to help the neophyte student construct appropriate meanings from texts—and that a central activity of any teacher, including teachers of science, is as a teacher of a new language (Osborne 2002). Indeed, one of the failings of much contemporary pedagogy in school science is an overemphasis on manipulating the material world rather than exploring the interpretation of data (Watson et al. 2004) or the language of science (Lemke 1990). But in what sense is reading an act of inquiry?

'Inquiry' is a term used to describe a range of actions. Rather like the term 'scientific literacy' no single definition exists. Linn et al. (2003: 4) offer one such definition which is more comprehensive than most:

> 'we define *inquiry* as the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments. In science inquiry projects, students communicate about scientific topics, evaluate scientific texts, conduct investigations, ask questions about

science and technology policies, create designs, and critique arguments, often using technology resources.

In short, inquiry is a process requiring a multiplicity of actions. Norris and Phillips position, which is cogently argued, is that reading (and writing) are activities which are central to inquiry and their legitimate criticism of the definition offered above might be that it only tacitly acknowledges the role of such activities. Indeed, how many of these activities are necessary or how many are sufficient to constitute engaging in inquiry is open to debate. Whilst reading, from the perspective of Norris and Phillips is definitely a process of inquiring into meaning, and the process of constructive interpretation of text may well require the reader to generate inferences it is difficult to see how it itself can be seen *as inquiry*. For example, the construction of argument is a core process of scientific inquiry—that is it is part of the process of inquiry but it is not inquiry itself.

Another premise running through much of the work of this group of authors is a belief in the validity of offering students to engage with 'authentic scientific practices'. By engaging with authentic or adapted authentic texts, it is argued, students will develop a better understanding of both the content and process of science. There are two potential dangers here. The first is that there is an assumption that an effective, or even the most effective, manner to learn science is by replicating the practices of scientist themselves. That this is a non sequitur is clearly demonstrated by the argument that there is no requirement for the literary critic to have been an author herself or for the sports commentator to have excelled at sport. The primary goal of science education should be to provide students with an understanding of the major explanatory theories that science has to offer about the material world, why they matter and the means by which such accounts are justified. Clearly the ability to read primary literature is a requirement for the practicing scientist but it can only be justified in school science if it contributes to the aforementioned goal. Criticism of any text to be used for learning science should rest on the intrinsic quality of the text itself and not on the fact that it fails to emulate the texts that scientists read. As Sartre (1969) argues, authenticity is not a given but has to be earned and results from a commitment by the individual to seek understanding and purpose in any activity—a view which is captured more by seeing the individual as engaged in a process of 'authentication' of any activity—the outcome of a process—rather than engaging with a context or materials that someone else has judged to be 'authentic' (van Lier 1996). What this means is that:

> 'One cannot say that any particular teaching method is more likely to promote authenticity than any other, regardless of whether or not it promotes the use of 'genuine' materials. Rather, the people in the setting, each and every one individually for himself or herself, as well as in negotiation with one another, authenticate the settings and the actions in it.' (van Lier 1996: 128)

Thus introducing APL literature into a classroom does not, of itself, transform the student experience into something that is an authentic experience of science. The two contexts are differentiated by two fundamentally different goals. One, the research laboratory, seeks to create new knowledge whilst the other, the school classroom, is a context for developing student understanding of old knowledge. What the learner seeks, rather, is an 'authentic' learning experience. One in which their knowledge is enhanced, their comprehension is enlarged and which offers an experience accompanied by a feeling of success, revelation and meaning. Granted, the evidence would suggest that much of school science education too often fails to achieve such goals with its lack of perceived relevance and the dominance of a transmissive pedagogy (Lyons 2006; Osborne and Collins

2001). But the belief that the APL materials, because they model the texts that scientists use, will be perceived as authentic by students reflects the values of these authors which may or may not be shared by the students themselves.

A key ingredient of 'authentication' is providing environments which foster autonomy and support students in developing a critical awareness of the language of the discipline. In that, these papers provide evidence that engaging with APL does develop the latter, then this approach can be said to enhance the possibility that the learning experience they offer will be perceived as authentic. But, as Norris et al. (2009) are finding, their use needs to be carefully scaffolded and designed.

Perhaps a final question arises from the paper offered by Jiménez-Aleixandre and Federico-Agraso (2009). Their work begins by examining the argumentative structure of the paper published by the Korean group led by Hwang and his collaborators in *Science* in 2004. This paper argued that their work provided evidence of 'the pluripotent human embryonic stem cell line' which had been derived from a 'cloned blastocyst'. The first problem is that it is impossible to construct meaning from this sentence unless the reader brings to it a body of relatively sophisticated background knowledge about the meaning of such terms as 'embryonic' or 'blastocyst'. Lacking such knowledge, most readers are reliant on knowledge intermediaries—generally science journalists with good scientific backgrounds—to translate these terms and construct models using referents which are more familiar to the lay reader. This is true regardless of whether the work is to be used for the project espoused by these authors—adapted primary literature or for journalistic mass media reports. The distinction is essentially only one of the degree to which this has been attempted. As Jiménez-Aleixandre and Federico-Agraso note, what occurs in this process is that certain elements become lost in translation. As Montgomery (1996) points out:

> 'Toning down the use of technical terminology in scientific discourse invariably means the elimination of detail and subtlety. Details in science, however, are not embellishments; they are information, facts, points of logic, twists of theory, and the like, and their deletion means, without exception, loss of knowledge. (Montgomery 1996: p 10)'

Thus, in representing Hwang et al.'s findings for a lay audience, the emphasis in the original paper for the substantive claim is diminished while the potential application is foregrounded. In addition, some evidence is omitted. Jiménez-Aleixandre and Federico-Agraso's finding that this is how the text is read by students is, perhaps then, not surprising.

Indeed, it is such journalistic reported versions (JRV) that the overwhelming majority of students will need to read critically in their lives. Surely, the issue then is, not how it has been distorted in such JRVs? This is inevitable. Rather, is it not how might students learn to read such reports critically? If so, it is providing students with the opportunity to compare the meta-structure of the original version and the versions articulated in JRVs and to discuss how the JRV might be evaluated that is important. That such skills need to be developed was shown by the work of Zimmerman et al. (1999) which revealed a sharp disparity between the constructs that experts were thought to consider significant in reading JRVs and what students thought were important. Whereas the experts thought that understanding the social context, the methods, how the research was related to previous research, and its potential relevance were all important factors and that the underlying theory and data supporting the claim were unimportant—mainly because they are absent in such reports—the students thought the converse. The question raised by this discussion then is one of objectives and the means to their attainment. The authors of these papers see APL as a means to developing a better understanding of both the conceptual content and the epistemology of science. My question is simply one of whether this kind of conceptual understanding is what is needed and whether a knowledge of the reasoning and argumentative structure of primary literature will ultimately be helpful in evaluating media reports of science?

It should be made clear that these arguments are advanced not to diminish the importance of such work. The work is valuable first because it recognises that texts are central to any understanding of science and that helping students to read the texts of science whether they be textbooks, APL or media reports of science should be a part of any education in science. Second, it advances or extends a line of work on reading in science which has its origins in the work of Davies and Green (1984) and which remains undervalued both by practitioners and researchers. Thirdly, like all good work it raises more questions than it answers—a few of which I have explored in this brief response. I hope that the reader and the authors will appreciate that the value of the comments and points developed here, if any, lies in the spirit articulated by Bachelard (1940) that 'two people must first contradict each other if they really wish to understand each other. Truth is the child of argument, not of fond affinity.'

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