

Discourse, language, and identity

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Us

Most of us who work in science education did well at it at school and enjoyed it sufficiently to carry on with it after school. And yet 'science' is not a single entity. If I think of myself, although I did reasonably well in chemistry at school, my heart wasn't in it and while my vacillation between physics and biology is indicated by my changing from the former to the latter during my first year at university, I never, so far as I can recall, consciously considered studying chemistry beyond school level. Looking back now, I can see it was the organic chemistry that was the problem. While I enjoyed the inorganic chemistry – those elegant rules for balancing equations, calculating heats of reaction and determining whether an endothermic reaction would proceed or not, not to mention the attractiveness of the practical work – much of carbon chemistry was a mystery to me. I realised subsequently that the problem was my poor powers of three-dimensional visualisation. To this day I have to use a map when driving to visit my sister several times a year despite the fact that neither she nor I have moved homes for nigh on thirty years.

Is it valid to say that I had a problem with the language or discourse of organic chemistry? At first sight the answer might seem to be 'no' – I knew what an alkane and an alkene was (I can still remember) and I was comfortable with the idea of chemistry, even organic chemistry. Indeed, I managed adequately to avoid having to rely on visualisation to just about cope with most of the questions my teachers or the examinations posed. And yet the sub-discipline felt 'like a foreign language' to me.

I start thus partly because starting where we are is never a bad idea in education (it can be easier to understand one's own problems than those of another) and partly because the above raises for me questions about what we mean by 'language' and 'discourse', let alone 'identity'.

The chapters in this section

The three chapters in this section complement another well. Two of them, by Cory Buxton *et al.* and by Emily King and Julie Bianchini, present original data and then use these data to draw more general lessons about language, particularly lessons about how rich approaches to science teaching can enable bilingual learners successfully to be included in science. The third, by Bryan Brown, proves a more conceptual analysis of how language and identity relate and ends by providing a clear model to suggest how students' learning in science might be helped.

Cory Buxton, Martha Alleksaht-Snider and Carlos Rivers analyse findings from their work to develop a bilingual outreach and research project focused on science, language and Latino families. They employed a model of instruction that drew together three strands: the mutual engagement of students, parents and teachers in bilingual science learning and preparation for college; authentic science practice; and academic language development to support language-rich science enquiry. Encouragingly, the project resulted in increases in student interest in science and a greater realisation among both students and their parents that they did, in their out-of-school activities, engage in science. For instance, during the initial interview at the start of the project nearly all of the examples parents gave of their having an interest in science came from the life sciences. In the final interview, parents expressed a much wider array of science interests including meteorology, kinesiology and environmental science.

Emily Kang and Julie Bianchini examine two 8th grade teachers' physical science classrooms to explore how English learners and students fluent in English negotiated issues among language, concepts and processes. Each of the teachers was well known among local educators for implementing inquiry instruction. However, all four of the investigations implemented by the two teachers were teacher-directed. More positively, students did not spend their time undertaking remedial tasks or individual seatwork. Instead, they had opportunities to work with more knowledgeable others (science graduate fellows and teachers), design and test structures, collect data, present their findings and argue their claims. Although some of the research findings were contradictory, there were encouraging signs that English learners benefitted from the inquiry approach.

Bryan Brown begins with 'the Language Identity Dilemma' in science education, namely the idea that the need to acquire new science language presents students with a learning challenge of two sorts. On the one hand, students must develop a clear understanding of science phenomena and their associated discourse. On the other hand, the nature of language-identity relationships presents students with a need to adopt the identity relationships associated with using science discourse. For some students, this works well. However, for many student populations the use of complex science discourse entails a substantial cultural shift that can produce identity conflicts. Bryan's propose solution, the 'Disaggregate Instruction' approach, begins by introducing new science ideas in the language that students already understand. Students are thus able to gain a basic understanding of the ideas and experience less anxiety and frustration typically associated with teachers' exclusive use of new science language. Once the basic tenets of a science idea have thus been taught, the teacher introduces the new science language. Finally, the teacher requires students to use their new science language to explain the phenomenon in meaningful contexts.

I would like to use these three papers as a springboard to allow me to explore a range of issues about language, discourse and identity. I do so as someone whose first language is English but who has never lived for any length of time in the USA. At

the same time, I shall try to keep in mind that language (even if narrowly restricted to words, eschewing other sounds and issues of multimodality) is concerned with what is said, heard, written and read.

Language

What issues does language raise for science education? Perhaps the longest established is that science generally has a very precise use of language. If one thinks of high school physics, we expect students to appreciate the difference between words such as 'force', 'power' and 'energy'. Yet these words are used in everyday language as near synonyms. Of course science isn't alone in this regard (the new Director of the Science Museum in London told me last week how, as an art historian, he had been ticked off for referring to a deposition as a *pietà*). Most subjects have a specialised vocabulary that needs to be used with precision. And yet science is distinctive in a number of ways. For one thing, as indicated by the force / power / energy example, it often takes everyday words and invests them with a very particular meaning. Of course, if you are an undergraduate studying an option in nuclear physics, you aren't going to be confused by the distinctive use of words like colour and charm when talking about quarks but earlier in one's science learning career this is more of an issue. The same point arises with the precise use of words like 'melt' and 'dissolve', with less familiar words such as 'assimilate' and 'reactant', and with phrases such as 'dependent on' and 'in proportion to'.

How does this connect with equity? For a start, and as indicated by Buxton *et al.* and Kang and Bianchini, those whose first language is not that of the science classroom (including, I would add, those who are Deaf, hard of hearing or disinclined / unable, for whatever reason, to listen or read attentively) are likely to be disadvantaged, as in any language-rich subject – which includes most school subjects and all those valued as academic, though perhaps less in the case of mathematics where a smaller vocabulary may suffice and where much communication is through the use of numbers and the explicit use of symbols, such as $+$, $-$, $=$, ∞ , \pm , \geq , x , y , π , θ , \therefore , \cup , \sum and \int .

This, of course, connects with the notion of cultural capital. If I have never seen a gyroscope, looked down a microscope or played with a chemistry set outside of school, I will be disadvantaged when I am first introduced to such experiences in school even if I initially find such school experiences as interesting as someone who has already met these scientific artefacts.

But deeper considerations of how language in science can marginalise and exclude are better explored through the notion of discourse.

Discourse

Science is full of powerful discourses. As with most discourses, these are most influential when unexamined. A particular problem with some who teach or research science is that the seductive benefits of a scientific approach are such that science is seen as all encompassing so that other ways of understanding are rejected. I'll illustrate this, and suggest more positive ways forward for school science, by reference to teaching about evolution and about sex.

Teaching about evolution

Teaching about evolution is becoming something of a battleground in an increasing number of schools, and not just in the USA. There are a number of relevant issues. First is the fact that, as someone with a PhD and post doc in evolutionary biology, I am of the view that it is important that students in high school are taught that to the overwhelming majority of scientists, the theory of evolution is extremely well established. There is only one scientific story in town and that is that the Earth is of the order of 4.6 thousand million years of age and that all species have descended from simple ancestors, indeed, ultimately inorganic precursors.

But how are science educators who accept this scientific consensus to react to those, whether students, their parents or others in the community, who do not accept the scientific account? For a start, I would argue that science educators must do nothing to ridicule or denigrate those who understand the world very differently from them. Not only is this discourteous and inappropriate for someone in a position of educational authority, it is counterproductive from a pedagogical standpoint. Indeed, for all that teaching about evolution makes additional demands on a teacher when some in the class are creationists or accept intelligent design theory, it can provide an opportunity for high quality science teaching. After all, if a student can argue for a young Earth or that species do not share very different ancestors, that can provide an opportunity for a teacher to encourage the scientific evidence on these matters to be examined.

I suppose I should add that this does not mean 'teaching the controversy'. Rather, the point is that it is (at any rate should be) in the nature of science to be open to critical examination. No student is being disruptive, let alone sacrilegious, by questioning evolution. Nor, in my view, is it the job of a science teacher to attempt to convert (my use of language here is intentional) their students to an acceptance of the theory of evolution. Rather, a teacher's objectives should include getting their students to appreciate what the theory of evolution is, what the evidence in favour of it is and how scientists counter some common objections concerning it (e.g. that mutations are always harmful, that the fossil record fails to show intermediate forms, and that the second law of thermodynamics disproves it).

So the theory of evolution is part of the mainstream discourse of science but it is also part of the discourse of science (or should be!) to encourage debate grounded in empirical evidence and supported by valid reasoning.

Teaching about sex

Sex in school science is mostly taught through the topic of reproduction (though it may also appear in the topic of disease via sexually transmitted infections). Immediately, sex is presented as binary and through a heteronormative lens. That sex exists as a binary – each of us is either male or female – is so obvious a ‘truth’ that it cries out for school science education to trouble such a notion. I am not arguing here that high school students should be introduced to Judith Butler’s texts (though some would benefit from reading *Undoing Gender*) but there is great opportunity when introducing standard biology to provide a richer understanding (and questioning) of sex and gender than is usually the case.

For a start, not all of us are unambiguously XX or XY (plus 44 autosomal chromosomes in each case). In my experience of teaching biology to 16-18 year-olds, many are fascinated by the range of chromosome conditions that some humans have (XO, XXY, etc.). In addition, learning about mosaicism (where one individual has cells of more than one genotype) can be illuminating and make what is otherwise a rather dull lesson on the stage of mitosis (remember the scene in *Twilight*?) of far more interest.

Then it is good for students to understand that in early development there are no discernable differences between males and females. It is only towards the end of the second month of pregnancy that the action of sex hormones results in sexual differentiation. Indeed, a whole range of factors can lead to intersexuality, something many people are now more comfortable with than was the case a few decades ago in the West when so-called ‘corrective’ surgery was typically unquestioningly employed – sometimes with what seems to have been successful outcomes but sometimes with what were undoubtedly not.

Moving on to the teenage years, the great majority of school textbooks make little or no reference to any sexuality other than heterosexuality. Such omissions are difficult to defend. Of course, I realise that teaching about anything that is sensitive or controversial can be difficult for educators but it can also be profoundly affirming for some of one’s students. And science has a very particular part to play. Even if one adopts a fairly conventional notion of science that sees it as ethically and politically neutral, science can still play an emancipatory role by enabling people to ask factual questions that demand objective answers. Is it the case that all people are either male or female? Is everyone heterosexual (in few societies now do all people answer affirmatively)? Does sexual orientation exist in discrete forms or sit on more of a continuum? And so on.

Identity

I began by pointing out that science is not a single entity. At one level, this is a trivial point. Even at school level, physics and biology are different in terms of how they are

perceived by most students and whether or not students find them engaging. Among professional scientists, there is rather little in common between a theoretical physicist, a molecular biologist, an epidemiologist, and someone who tests for water quality before we even start to consider whether physical geographers, psychologists, and anthropologists are scientists or not.

And yet, there is a powerful discourse within science, backed up by a common language and appeal to that mythical notion of 'the scientific method', that conveys an image of science as a monolithic beast, relentlessly advancing and devouring other, older, more local, more subjective forms of knowing.

Such a discourse is attractive to some and yet excludes many. But there is another way. Science, precisely through its commitment to the use of experimentation, its spirit of open-ended enquiry and its attempt to remain above party considerations, has the potential to serve as a tool of emancipation. Given the near inevitable tendency for societies to marginalise and stigmatise those who are in minorities and positions of little political power, science offers hope for those of us who do not fit comfortably into 'the majority'.

And by the time one adds up all the minorities (the term being used to include those in unequal positions of power as well as in numerical minorities) – women, those with a minority religious faith in religious societies or with no faith in religious societies, those with disabilities, people of colour, the young, the old – one finds that the great majority of people belong to at least one minority camp.

It is vitally important therefore that school science indicates its value for those of minority identities. This, of course, is not to essentialise or rigidify identity. Most of us can accept that identities are fluid (without being entirely shapeless). The point, rather, is that science is big enough to provide a comfortable place for a very wide range of students. When students say, as many of them do in the richer countries of the world, that they find science 'boring or 'irrelevant', what they are saying is that they cannot see the connect between what they are taught as science in schools and the issues they face or who they want to be. Schools science thus often has an identity problem: it fails to relate adequately to students' evolving identities.

My point is that good science teaching should enable students to realise that far from needing to reject science, science can provide a space for them to grow into who they want to be. Science can problematize cultural assumptions about what is desirable without minimising the strength with which these assumptions can operate. Consider, for instance, race/ethnicity. Perhaps unsurprisingly, race/ethnicity are really considered in school science. And yet they are often core to how we see ourselves. School science could provide an opportunity (though I appreciate such teaching can be difficult) for students to explore what biology has to say about race (we are into locally adapted genotypes and genetic drift here) and whether or not differences between groups are large or small. They are small, despite what some conservatives hold, but not, despite what some liberals hold, trivial: there are important medical correlates with race/ethnicity and denying this or, more typically,

failing to address this in school will help no-one, particularly as personalised genome studies, and perhaps therapies, become more widespread.

More generally, students, whether conceived of as minority or majority students, should be encouraged and supported to think, read, write, listen and talk critically. 'Critically' here can be understood in two senses. First, as meaning that the evidence for an assertion is to be examined rigorously. Science, fundamentally, is not about rote learning but about knowing how to test certain claims about the world. There is little point in learning that the Earth goes round the Sun rather than vice versa unless one can adduce evidence in support of this claim. It is one thing to know that proteins are an essential component of our diet; it is another to know how this was established and to understand why nucleic acids (despite being essential for life) are not.

The second sense of 'critically' is more to do with equity. A critical examination of biodiversity might include looking at which countries have lost in the past and are now losing the highest proportions of their native fauna and flora both. A critical study of health in a US state might include examining data on mortality and morbidity by gender, ethnicity, age, occupation, home language and residential area.

Finally, students are most likely to develop an understanding of science, an ability to use the languages of science and an appreciation of the discourses of science when they are given some autonomy in their learning so that at least some of their efforts in their science work can be devoted to issues of personal significance. Curriculum developers and teachers sometimes seem to shy away from this, perhaps fearing that boys will spend all their time writing projects on explosive chemicals and girls all of theirs on issues to do with health.

I would respond to this perception in three ways. First, gender and other student differences in topic preferences are not as absolute as is sometimes presumed. Secondly, I am only talking about some time being given over to students to choose on what they work. Thirdly, given that the great majority of school students drop science once they can, it might be wiser to do what one can to engage students, rather as teachers of fiction nowadays seem comfortable with a greater range of authors and genres than when I, at any rate, was in school. Furthermore, giving students more choice on what they work often leads to greater co-operation between interested students, to greater involvement of their families in their science learning, and to a better connect between formal and informal sources of learning in science.