Ways to prepare future teachers to teach science in multicultural classrooms

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Abstract

Roussel De Carvalho uses the notion of superdiversity to draw attention to some of the pedagogical implications of teaching science in multicultural schools in cosmopolitan cities such as London. De Carvalho makes the case that if superdiverse classrooms exist then Science Initial Teacher Education has a role to play in helping future science teachers to become more knowledgeable and reflective about how to teach school students with a range of worldviews and religious beliefs. The aim of this paper is to take that proposition a step further by considering what the aims and content of a session in teacher education might be. The focus is on helping future teachers develop strategies to teach school students to think critically about the nature of science and what it means to have a scientific worldview. The paper draws on data gathered during an interview study with 28 students at five secondary schools in England. The data was analysed to discover students' perceptions of science and their perceptions of the way that science responds to big questions about being human. The findings are used to inform a set of three strategies that teachers could use to help young people progress in their understanding of the nature of science. These strategies together with the conceptual framework that underpins them are used to develop a perspective on what

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kinds of pedagogical content knowledge teacher education might usefully provide.

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Superdiversity and science teacher education

Roussel De Carvalho draws a detailed picture of the issues and concerns that can arise when teaching science in multicultural schools in cosmopolitan cities such as London. As De Carvalho points out teacher education can enable future teachers to become more knowledgeable and reflective about the range of beliefs that young people are likely to hold and can help teachers develop effective strategies to engage with multiple worldviews and discourses in their classrooms. In this paper, I will build on this proposal to consider some ways that teacher education can help teachers in these regards. In choosing a topic and theme to explore, I am not attempting to provide a comprehensive approach but rather a starting point for an exploration of relevant themes and topics. My selection is informed by an interview study which reveals some of the beliefs that secondary school students hold about what it means to be human and the extent to which they see these beliefs as compatible with what they perceive to be a scientific worldview. When I turn to the question of how science teacher education can help future teachers prepare to teach in multicultural classrooms, I will stay with this theme (what it means to be human) and will identify three strategies that teachers could use to help students develop their understanding of the nature of science. These strategies were developed as part of a project that is creating cross-curricular workshops for school students.

Identifying an objective for students' learning

For this discussion my focus is on how teachers can help young people advance their understanding of the nature of science and, particularly, their capacity to think critically about whether science can foreseeably one day address all the questions humanity has. Learning to question and appreciate the power and limits of science is an objective that is included in the National Curriculum for Science in England for students in upper secondary school (DfE 2014).

The context I am choosing for this objective is the question 'Will science one day fully explain what it means to be human?', where the phrase 'what it means to be human' is a broad category to encompass whatever ideas school students might hold about how to describe and explain human experience, behaviour and thinking. It is an important context for science teaching because young people frequently encounter news of advances in evolutionary biology, neuroscience and genetics in their lessons and via the media. Many of these stories raise questions about what it means to be human by, for example, raising the possibility that our thoughts and behaviour can to a greater or lesser extent be explained scientifically. As such, there seems to be a potential for a significant proportion of young people (both with and without a religious faith) to be influenced and concerned by what they perceive science to say. I am proposing this topic as a useful starting point in a session for preservice science teachers not only because of the potential for news of scientific advances to affect school students' personal beliefs but also because I am looking to draw attention to the potential for important differences between how young people perceive science and how science is described in scholarship. Previous research by Astley and Francis (2010) suggests that investigating what students perceive to be the position of science on such matters is important because when students perceive science to be incompatible with their own positions it can have a negative impact on their levels of engagement and their attitudes to careers in science. Thus I argue that science teachers should be interested in what young people perceive are the presuppositions underpinning a scientific worldview.

To date there is very little research which looks at how reports of scientific advances influence students' perceptions of what it means to have a scientific worldview. In contrast the impacts of neuroscientific and genetic findings on adult society have been considered by a wide range of studies. For example, Eric Racine et al. (2005) have coined the term 'neuroessentialism' to refer to the way that fMRI findings influence public perceptions of what constitutes personality by equating personality to characteristics of the brain. There are also studies in the field of genetics which have shown that people can believe that actions and even crimes are attributed to genes rather than agents and conclude that they are not acts for which responsibility can be attributed (Monterosso et al. 2005). Here, as I indicated previously, I am not only interested in how news reports of scientific advances influence students' beliefs about being human, but also how such reports influence their perceptions of science.

Conceptual framework

The conceptual area that is of interest in the current context is the possibility that a significant proportion of students are poorly placed to appreciate that having a scientific worldview does not necessitate a commitment to scientism. Scientism has been defined in a number of ways and a useful description provided by Mikael Stenmark (2001) is that it is a stance that science will one day provide a full account of the universe and its habitants. When thinking about what it means to be human, scientism frequently relates to a metaphysical commitment to reductionism which is the idea that, “where we thought we had two sets of concepts, entities, laws, explanations, or properties, we in fact have only one, which is most perspicuously characterized in terms of the reducing vocabulary” (Charles and Lennon 1992, p. 2). As such, in this context, it is the view that human beings are “no more than a vast assembly of nerve cells and their associated molecules” (Crick 1994, p. 3).

Scientism is not, however, a necessary presupposition of science (Stenmark 2013) and there is value in helping young people to appreciate that scientists hold diverse opinions on the extent to which science is a sufficient way to investigate and understand the universe.

Expressions of reductionism that are made or referenced in scholarship include neurosessentialism and geneticism. Neuroessentialism argues that the apparent freedom of a human mind is an illusion created by the complexity of the brain’s operations – in other words, that “the mind is what the brain does” (Pinker 2000, p. 183). A variation of the idea is that our mind is not anything more than a soggy computer (Jones 2013).

Geneticism is the idea that genetic explanations are fundamental to explaining human nature and human characteristics and is a version of strong biological reductionism. Determinism as a metaphysical view is sometimes associated with genetics. Johannes Keller (2005) explains that instead of seeing genes as a factor among other factors that determine a particular behaviour, feeling or thought, people may see genes as determining outcomes. In parallel with our contrast of science and scientism, genetic findings are compatible with a wide range of metaphysical views. The conflation of genetics with geneticism has been criticised by biologists such as Ruth Hubbard (1999). Another biologist, Professor David Lahti (2012) conjures the analogy of bread baking to represent his view of how three constituents of personhood (nature, nurture and agency) develop and interact. In his analogy the ‘flour’ of genetics, the ‘water’ of environment and the ‘yeast’ of agency are combined, and although the yeast may not apparent in the product, it is as essential as others.

Are students making these connections: findings from research

To gain an insight into how and whether these matters might apply for secondary school students, an interview study with teenagers in five secondary schools in England was conducted by the LASAR (Learning about Science and Religion) project. The 28 students taking part in the study were aged about 16 and were selected by their teachers who in turn were asked to select students with a range of religious and non-religious stances. The interviews were recorded and transcribed with participants’ and parents’ permission. Before analysis, participants’ names were replaced by pseudonyms.

One of the aims of the interview study was to discover what types of questions and concerns students in this age group have, if any, when they consider what science seems to them to say about what it means to be human. To give students a structure to work with, the interview schedule presented a series of themes and stimuli as well as open questions.

One theme raised in the interview was the question of whether humans have free will. A majority of students demonstrated an awareness that this is a contested area and in their explanation, referred to a reductionist position. Within that group many also said they see the reductionist position as both credible and unsettling. Here is an example:

Raminder: I'd still believe it's free will instead of just a mass of atoms, but I think it's because I like to believe that. I like to believe it's free will because then it shows that […][1] there's more of a purpose to life.

There were also some students who said that scientists would necessarily adopt a reductionist position on this question.

Phoebe: I've heard about the thing that we don't really have free will, and everything's kind of predetermined. But I don't really think that's true. I mean, when you put it like that all scientifically, it sounds like it could be. But I just wouldn't like to believe that because it does feel like we're making our own decisions.

Interviewer: What do you believe a scientist would say about that [free will]?

Phoebe: Perhaps they would say it [the brain] is just a complex thing made up of cells, and there's no actual aspect of it that would say oh free will. You know, there's not a little free will section of your brain.

The notion that scientists would find it difficult to accept the existence of something unless they could physically observe it arose again in an interview with Jack during a section where he discussed his view on the existence of the soul. Jack explained that scientists would find it difficult to accept the existence of the soul.

Jack: It would be very difficult for them to do so, especially with these beliefs, but also the beliefs about the soul and the fact that it isn't a physical substance really, I think it would be difficult to really learn more about it. I mean they've done well to learn about gases which we can't see so maybe, possibly, they could learn more about the soul. But […] as far as I'm aware, most scientists wouldn't necessarily think there was a soul and go out and investigate more about it.

Jack explained that in his own view "we are more than just a pack of neurons, I think we are much more special than just that." When, however, Jack reflected on

[1] In this manuscript, "[…]" is used for words omitted and "…" for a substantial pause.

what scientists might think about the idea that humans are packs of neurons, he said, “I think quite a few scientists would probably take that viewpoint really because I mean if you just look at the physical state of us, we are really are just a pack of neurons really I think, so I would think quite a few scientists would take that view as well, yes.”

Another part of the interview that stimulated thoughtful responses asked participants whether they perceive the mind to be the same as the brain. As the following illustrative examples demonstrate, in most cases students were able to make sense of the question and appreciate that there is a philosophical dimension to the enquiry. It is also interesting to notice that some students find it difficult to articulate their ideas.

Poppy: I probably wouldn’t say there’s much difference between them. I mean mind is a result of your brain, you know. Yeah, I would say they're one and the same really.

Opinder: I think the mind … the brain is more … it’s hard to explain. The brain is more of a … everyone thinks of it as more scientific, and the mind is more … it’s more like a soul kind of … all your personal thoughts … It’s hard to explain.

In the following quotations two students consider whether or not it might one day be possible to use science to predict what a person will think and do next and draw parallels between computers and minds which are consistent with a reductionist view:

Phoebe: I think through science in a century or so it would be possible as the mind is basically like a supercomputer sending messages around the brain and it’s made up of millions of connections.

Richard: I think it is possible [to predict human behaviour], because the mind ... in a way, we are like robots … I think it is possible to predict what the mind is going to do.

The data also revealed one of the ways in which students’ epistemic insight can progress. One student in the cohort explained that his thinking has progressed over time to a point where he now appreciates that the terms mind and brain are not necessarily referring to the same thing:

Matthew: When I was younger, it was like the words ‘world’ and ‘earth’. ‘Earth’ is a more scientific word for ‘world’, the same as ‘brain’ is for ‘mind’. But now I think of mind as more of a spiritual aspect as well. The brain is what you say when you are talking about the actual physical and biological parts of your thoughts and everything. But mind is more of a ... it’s sort of the aspect of human choice and free will.

Taken as a whole, these comments suggest that students in this age group are likely to vary in their capacity to appreciate that science is consistent with a range of metaphysical positions and to have a range of levels of insight into whether and why science is compatible with a range of worldviews.

Three teaching strategies that build on this picture

The learning objective I am proposing for science teachers to take into classrooms is: 'For students to consider and appreciate the power and limits of science in the context of what it means to be human.' In this section I offer three strategies that teachers could potentially use to help students advance their understanding of the nature of science in relation to this theme.

Strategy 1: To help students to become familiar with terms and language that can help them to recognise and compare reductionist and non-reductionist approaches.

My discussion of the interview data concluded with the idea that students need to appreciate that mind and brain are not merely synonyms if they are to form a considered position on whether or not investigating the brain is equivalent to studying the mind. An example of a strategy to achieve this would be to ask students to come up with pairs of scientific and non-scientific words that seem to them to be related. Examples are 'brain and mind', 'characteristics and qualities' and 'earth and world'. Students could also suggest words that seem to them to mean something different inside science and outside science. Examples are the terms, power, behaviour, materials and theory.

At this point the teacher could explain that by selecting some words and some meanings of words, phrases and questions, the scientific community frames an enquiry that science can feasibly address. Some teachers may choose to go further and prompt students to think about a question that could be framed differently in different disciplines. An example is the question, 'Why did the Titanic sink?'. A scientist working with this question might want to model the ship and iceberg and investigate the forces that could tear a hole in the ship's side. A historian might be interested in the circumstances that meant that the Titanic was in that area at all. This idea that questions are framed differently by different disciplines could be a starting point for a discussion which explored the power and limits of science.

Strategy 2: To establish with students that choosing to think scientifically does not mean you cannot call on multiple ways to address questions.

Science teachers may have opportunities to collaborate with colleagues to build students' appreciation of the way that disciplines can work together to paint a rich picture of what being human means. The activity I offer here is taken from a day of cross-curricular workshops that LASAR organises for teenagers on science and big questions. The workshop begins with the facilitator writing the question 'why is my hair the colour it is?' on a board. Students are asked to notice that this question can be asked in each of a number of disciplines such as physics, chemistry, biology, theology, history, psychology and philosophy. Students then suggest how a scholar in each of these disciplines might investigate and address the question. As they give their responses, each discipline is written on the board, so that altogether they form a circle around the question. Students are asked to indicate which type of answer they prefer and why. They are also asked whether someone could accept answers from more than one discipline at a time. The facilitator then removes the original question and replaces it with a new question: 'Who am I?'. Students are again asked to suggest how a physicist, a chemist, a historian, a philosopher, a theologian and so on might answer this question. The discussion concludes by noticing that many disciplines contribute to a common endeavour to construct knowledge and invest life with meaning. Students who attended this workshop provided feedback that was overwhelmingly positive. One such comment from a student was

The session that most changed my thinking was 'all you need is science or is it?'. My opinion changed greatly on the question 'who am I?' At the beginning of the lecture I instantly said, I'm a biological being made up of particles and in the end I realised (in my view) that I'm the produce of my history not just some clump of molecules. The session … changed my point of view and I thoroughly enjoyed myself.

Strategy 3: To establish with students that accepting that personality is shaped by genetics is distinct from committing to genetic determinism

Given that biologists have a range of views on the extent to which science can explain personality, a lesson on human genetics might include equipping students with the insights they need to recognise and be critical of announcements of advances in genetics which assume a deterministic stance. Such terms can be found not only in media reports but also in numerous science textbooks (Castéra et al. 2008). Examples are when phrases like 'genetic programming' and 'genetic blueprint' are presented as a way to understand the person as a whole.

One of the workshops organised for LASAR presents students with a conundrum that was featured in an episode in the television drama series, 'Law and Order UK' (Goddard 2009). This episode tells the story of the trial of a 13-year old boy, Jono, who is accused of murder. At the request of the defence lawyer, Jono is tested and found to have the so-called 'warrior' gene. The viewer is also told that Jono's mother is his sole carer and that she has provided him with little or no moral instruction. Jono's defence lawyer argues that in the light of his genetic profile and upbringing, Joni cannot be held responsible for becoming violently angry and beating his friend to death as he had no capacity to control his behaviour. In the end the defence strategy backfires as Jono insists on changing his plea to guilty. He says his genes are 'rotten' and that nothing can be done to change him. He wants to be put into prison. The activity for students is to decide whether or not to accept the defence lawyer's case that, according to science, Jono had no capacity to behave in any other way than he did. In other words, does science say that a person's genetics and upbringing are the sole and determining factors – firstly in the case of Jono who has apparently been diagnosed as having a warrior gene, and secondly in the case of a child who does not have this diagnosis? To help them, students are given the support of a facilitator who attempts to answer their questions and short texts selected to illustrate different metaphysical positions. The advantage with a conundrum as the stimulus for the session is that its puzzling nature can motivate students to engage in an investigative cycle (White and Gunstone 1992) and students can then be prompted to consider new possibilities via questions posed to them by ‘more knowledgeable others’ – that is, their teachers (Smardon 2009; Vygotsky 1978).

Summary

The learning objectives for school students, subject knowledge and examples of student activities outlined here are intended to encourage trainee science teachers to consider strategies they could use to draw school students’ attention to the distinction between science and scientism. The aim of these strategies is to ensure that students have opportunities to critically examine the capacity of science one day to fully explain human experience. During such teaching it is important for students to know that there are not straightforward answers and that this is a highly controversial area where distinguished scholars disagree. One way to do this is to draw students’ attention to questions that are explored in scholarly debate while tailoring the ideas so that they are likely to be within young people’s intellectual reach (Perry 1970). It is also important to highlight that in such situations, education is to a large extent dependent on there being guidance from scholarship about what the key issues are, what principles need to be considered and what the key responses are. As such, the aim would be to provide learners with a pluralist introduction to a range of scholarly positions so that they do not come to see one view as being a norm or consensual view.

It is important to acknowledge that the strategies discussed here address only a portion of the concerns that may arise and also that the strategies teachers will want to apply in practice will depend in part on the settings in which they teach. In many schools the time available might extend beyond the formal lesson and it would be for teachers to decide which strategies are appropriate in a science lesson and which could be used in an informal setting such as a lunchtime cross-curricular workshop for students who choose to attend.

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