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## Science Education: Beyond a Liminal Understanding of Knowledge Production and Dissemination

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### Abstract

The present paper is a case study based on a first year BA Hons Education Studies module that explores a number of important questions about the relationship between technology, knowledge and society and begins to think about how our ideas about each of these contribute to an understanding of what education means. Following a Foucauldian perspective on discourse, truth and power, we look with our students at science – and science education – to explore the production of knowledge in a context where many initiatives promote scientific literacy for children and young people as an important factor in their educational upbringing. The paper argues that it is important to reflect with students on these forms of knowledge production and dissemination and so to avoid seeing and teaching science purely from a consumerist perspective; rather we embrace and develop the idea of science education as a discourse that shapes our understanding of the world and ourselves.

**Key words:** Science education, Knowledge production, Discourse, Power, Foucault

### Introduction

#### Science and Science Education

Science, in one form or another and intermittently, has been “a subject” at school level in many countries for centuries. However, this has not always been the case. In the past, science education was confined to a few seriously devoted people. As Das (1985) argues, this might have been the case because in the past science was considered as an inferior subject to study. In addition, ‘[n]ew ideas or inventions in science were not immediately accepted in the society and were looked upon with suspicion’ (Das, 1985, p. 3). For example, the idea that the sun was the centre of the Solar System advanced by Copernicus and developed by Galileo and Newton was, for a long time, regarded as controversial, especially by the Roman Catholic Church. This led to the idea that science, and especially scientists, were not to be trusted. Hence, science education, for a long time, was not considered relevant for “the masses”.

Now, we cannot think of a world without science. Science has become an integral part of our life and living. ‘There’s no aspect of man’s life today which has not been influenced by science one way or the other’ (Das, 1995, p. 2). Hence, in recent years, science education has become increasingly important, with the subject forming an essential part of school curricula. ‘Teaching of everyday science for everybody has become an unavoidable part of general education’ (Das, 1985, p. 2). As a result, new guidance has been developed that encourages schools to put science education at the centre of their attention. For example, in England the revision of in the ‘National Curriculum’ has put science as a subject in the foreground. The changes resulting from this revision come into effect for all Key Stage 1 and Key Stage 2 pupils from September 2015, and for pupils in Year 11 from September 2016 (Department for Education, July 2013).

The new ‘National curriculum in England: Science programmes of study’ states that ‘...all pupils should be taught essential aspects of the knowledge, methods, processes and uses of science’ (Department for Education, December 2014). This means, pupils should learn to understand the world through the specific disciplines of biology, chemistry and physics. ‘They should be encouraged to understand how science can be used to explain what is occurring, predict how things will behave, and analyse causes’ (Department for Education, December 2014). The aim is to ensure that all pupils:

- ‘develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics;

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- develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them;
- are equipped with the scientific knowledge required to understand the uses and implications of science, today and for the future' (Department for Education, December 2014).

For children in Key Stage 1 – the two years of schooling in maintained schools in England normally known as Year 1 and Year 2, when pupils are aged between 5 and 7 – this means to experience and observe phenomena by looking more closely at the natural and humanly constructed world around them. They are encouraged 'to be curious and ask questions about what they notice' (Department for Education, December 2014). Older children – upper Key Stage 2, Year 5 and 6 – are encouraged to develop a deeper understanding of scientific ideas: '...they should encounter more abstract ideas and begin to recognise how these ideas help them to understand and predict how the world operates' (Department for Education, December 2014). In Key Stage 3 – the three years of schooling in maintained schools in England normally known as Year 7, Year 8 and Year 9, when pupils are aged between 11 and 14 – pupils are encouraged 'to relate scientific explanations to phenomena in the world around them and start to use modelling and abstract ideas to develop and evaluate explanations' (Department for Education, December 2014). They should learn to pay attention to objectivity and develop concern for accuracy, precision and repeatability.

Although the UK Government – with the new curriculum – envisages schools and teachers taking greater control over what is taught in schools and how it is taught, using their professional skills and experience to provide the best educational experience for all their pupils, the new 'National curriculum in England: Science programmes of study' provides quite detailed guidance on the topics to be covered by schools. For example, in the Year 1 programme of study children should learn to:

- 'identify and name a variety of common animals including fish, amphibians, reptiles, birds and mammals;
- identify and name a variety of common animals that are carnivores, herbivores and omnivores;
- describe and compare the structure of a variety of common animals (fish, amphibians, reptiles, birds and mammals including pets)' (Department for Education, December 2014).

Hence, many feel that with the new science curriculum there is 'a shift towards hard facts and "scientific knowledge"' (BBC News, September 2014). Others argue that the new science curriculum is 'a "two-tier curriculum" favouring the core subjects of English and Maths at the expense of the arts and humanities' (The Independent, September 2013). However, in general it seems as if the new curriculum follows what Hodson (1993) has pointed out as the three main purposes of science education, that is, to come 'to understand the major achievements of science', the concepts, the models and the theories, 'to learn about science', to develop an understanding of the nature and methods of science, and 'to learn to do science', involving modelling and model testing – although some argue that the main purpose of science education in schools should be 'to increase the flow of specialist scientists, technologists and engineers' (The Association for Science Education, The Economic & Social Research Council & The Teaching and Learning Research Programme, 2006): a sort of sensitization and pre-professional training.

The purpose of this paper is to reflect critically on current science education with the help of a case study example in order to develop a more critical understanding of what science education might mean for "future educators". The paper argues that – in the light of the new English National Curriculum – the teaching of scientific knowledge should be more than the presentation of facts and figures, following Millar and Osborne (1999, para 4.2), who argue that '[t]he science curriculum from 5 to 16 [years] should be seen primarily as a course to enhance general "scientific literacy"'. This means that educators need to be able not only to teach scientific facts and figures, but also to raise questions of truth and power in relation to the subject itself in order for their pupils to recognize that scientific ideas change and develop over time. In our module, we use the Foucauldian theoretical position which focuses on discourse and its power to produce "truths"; we use this as a heuristic tool that future educators can use to diversify the teaching, learning and public understanding of scientific knowledges. We argue that it is therefore important not only to introduce prospective educators to science as a discrete subject area, but also to make them aware of the importance of discourse in shaping our understanding of the world and ourselves within it.

Here we follow Foucault, who argued that social processes are shaped (or constructed) in and by discourse, and in modern societies scientific discourse is highly valued and authoritative, which in turn points to existing power relations.

## **Foucault: Discourse, Truth and Power**

In our teaching we follow a Foucauldian perspective to explore the aims and objectives – and also implications – of science education with our students. We chose this approach because the concept of discourse allows us to re-pose questions about science education, and to explore the implicit and explicit power relationships at work when speaking about science as a subject. As Foucault (1981, p. 52) argues:

‘In every society the production of discourse is at once controlled, selected, organised and redistributed by a certain number of procedures whose role is to ward off its powers and dangers, to gain mastery over its chance events, to evade its ponderous, awesome materiality’.

Following from this, it is noticeable how knowledge should not be taken for granted and how through discourse we can elicit some of the pre-conditions to knowledge acquisition, validation and distribution in particular space-time continuums. Consequently, through atomising the notion of discourse, we can encourage our students to problematise scientific discourse-pervaded knowledges and to become more epistemologically relativistic about the subject of science and what the effects of those knowledges might be.

Theoretically, discourse, as argued by Foucault, transcends desire and institutions. Desire in relation to discourse is then understood as that subjective (circumstantial and often contextualised) position that we might find ourselves in; in any given moment we are juxtaposed and immersed with discourse(s). The institution, as Foucault (1981, p. 52) points out, is ontologically dependent on the production of a particular discourse; it replies to the individual by saying:

‘...we are all here in order to show you that discourse belongs to the order of laws, that we have long been looking after its appearances; that a place has been made ready for it ... and that if discourse may sometimes have power ... it is from us and us alone that it gets it’.

Significantly, the institution’s very own sense of existence is permeated by discourse production; the institution then tries to control discourse, and its production and distribution (or dissemination), yet, discourse has a more subversive and insidious power, which permeates desire (subjectivity) and institution (objectivity). Discourse in itself could then be understood as symbolically, representationally, semantically and concretely forming and constructing the objects of which it speaks and in doing so it finds itself outside subjective and objective positions. This means the study of discourse, as explored by Foucault, is linked to the historical institutions that embrace it, give it a voice, silence it or disregard it; discourse then forms not only the objects of a particular reality, but also determines how that reality is formed. Discourse creates knowledges and “truth”; it creates “a world” that is both palpable and also transformative.

For instance, if we take Foucault’s example of the historical opposition between reason and madness as represented by the ‘madman’ and his speech, we can appreciate how the scientific knowledges of psychiatry and psychoanalysis have emerged as a result of the continuous decoding of the evolving discourses around madness. But in this decoding there is still a very definite oppositional production of the conditions and characteristics associated with states of reason and madness. Foucault (1981, p.53) states:

‘Since the depths of the Middle Ages the madman has been one whose discourse cannot have the same currency as others. His word may be considered null and void, having neither truth nor importance ... It was through his words that his madness was recognised, they were the place where the division between reason and madness was exercised, but they were never recorded or listened to. No doctor before the end of the eighteenth century had ever thought of finding out what was said, or how and why it was said ... He [the madman] was only symbolically allowed to speak, in the theatre, because there he played the role of truth in a mask’.

This extract is pointing to how, although the madman’s speech was discredited, it still held a credited position within the institution of the theatre; there on the stage, was the madman’s place of worth, where his madness became mysticism and curse but still in its most rational form. Yet, it could be argued that this discourse is understood and decoded very differently now that the madman’s speech is no longer sitting easily on one side of the divide between reason and madness. This is because this discourse is now decoded by other modern knowledge-institutions which no longer immediately discredit the madman’s speech; rather it has significance in ‘...that it puts us on the alert; that we now look for a meaning in it...’ (Foucault, 1981, p. 53). The extract is further referring to the development of a whole system of knowledge, knowledge-institutions and knowing-subjects (people) who are now responsible not only for articulating the ‘madman’s speech’ but also for diagnosing and treating it. Of these knowledge frameworks we only need to think ‘...of the whole network of institutions which permit someone – a doctor or a psychoanalyst – to listen to it, and which at the same time permit the patient to bring along his poor words or, in desperation, to withhold them’ (Foucault, 1981, p. 53).

Following this example, it is argued that the madman's speech is the iconic representation which allows the institution to present possibilities for decoding it, it is not the subject, in this case the madman, per se, neither just the institution itself. Instead all these elements are interwoven and harnessed together by discourse; it is discourse which forms, transforms, validates and configures the institution, leading to the arrangements of "the subject". These arrangements and designs in subjects are particularly infused by scientific discourses, and by the institutions which are seen as responsible for actualising these discourses, as the example explored above explains.

In our teaching we use this Foucauldian understanding of discourse to analyse critically and re-pose questions about specific parts of scientific knowledge, and what the acquisition of these knowledges have allowed us to make of ourselves as part of a changing society, underpinned by varying and changing discourses. The problem that we present to students is not to do with drawing the line between truth and something else; in fact, the notion of discourse is pointing beyond this long-standing true-false opposition. Foucault (1994, p. 119) asserts that:

‘...the problem does not consist in drawing the line between that which, in a discourse, falls under the category of scientificity or truth, and that which comes under some other category; rather it consists in seeing historically how effects of truth are produced within discourses that, in themselves, are neither true nor false’.

Within this understanding we can open up possibilities to discuss scientific knowledge as discourse that is pervaded by power relations.

We, the authors of this paper, believe that conceptions of discourse and power relations are important theoretical tools which can help students to understand how we are in a state of flux – societally and culturally – and that the analysis of discourses can give a powerful indication as to how societal and cultural change is created and effected. Therefore, in the module ‘Culture, Curriculum and Technics’, we are moving students beyond what is normally covered in a first year undergraduate course by introducing them to evaluative, theoretical tools that help them understand that all systems of knowledge are subject to debate. These systems of knowledge are, as Foucault (1994, p.131) states, neither outside of power nor ‘lacking in power’. Following this view, we argue that systems of knowledge are systems of power because of the types of discourses that they are formed by and these discourses operate in exclusionary ways. Consequently, science education needs to have a strong and discernible criticality looking at the very

‘...mechanisms and instances that enable one to distinguish true and false statements; the means by which each is sanctioned; the techniques and procedures accorded value in the acquisition of truth; and the status of those who are charged with saying what counts as true’ (Foucault, 1994, p. 131).

In the light of this, science education can be regarded as a particular discourse of science and its truths, but ultimately, and following a Foucauldian perspective, is neither true nor static; it is infused with economic, political, social and ideological traits of our time. Conceivably, science education and education in itself are manifestations of discourses and knowledge systems.

## **Case Study: Education Studies**

For the purpose of this paper and to interject science education with a social science perspective we, the authors of this paper, decided to illustrate the contribution of discourse through this selected case study. Both of us teach on the BA Hons Education Studies at London Metropolitan University (UK). The BA Hons Education Studies takes education as a study object. This means, the course tackles philosophical questions concerning the place of education in the modern world as well as the detail of everyday professional practice in schools and other educational institutions. Hence, it addresses philosophical, sociological, epistemological and historical aspects of learning and teaching against the backdrop of education as part of changing societies. Through that, it prepares students for a range of socially responsible professional roles in a variety of settings – including primary, secondary and adult education, youth and community work and health and social care.

Students on the course traditionally come from a broad range of backgrounds, with many students choosing the course as a second pathway into professional teaching. As Blagburn and Cloutterbuck (April 2011) point out, London Metropolitan University (UK) is made up of almost 50 per cent non-traditional students. This is confirmed by internal statistics that show that the majority of students on the course come from a working-class and/or ethnic minority background. This means, students on the course have mixed abilities and interests – with many being unfamiliar with the theoretical frameworks used in academia – and science. They are ‘outsiders’

compared with ‘those who know how the system works’ (Pratt-Adams et al., 2010). Despite this, we like to challenge and develop their personal learning and understanding.

One of the first modules students on the course need to undertake is ‘Culture, Curriculum and Technics’ – a 30 Credit Level 4 core module that runs over 30 weeks, from September until May. The module was introduced in 2012 as part of a broader restructuring of the BA Hons Education Studies. The aim of the module is to present a range of theoretical perspectives and tools to students, which they can use to analyze a curriculum as a socio-cultural construction – and which also enable them to identify ways in which knowledge is produced, reproduced and transmitted. It is hoped that this enables students to move beyond a simplistic understanding of a curriculum as a set of subjects that need to be covered in a certain period of time towards a critical appreciation of knowledge and knowledge production in educational settings – including schools.

The module content is organised in blocks, six in total, which all address a specific question. These blocks are as follows:

- Block 1: What do we mean by culture?
- Block 2: What counts as knowledge and why do we educate?
- Block 3: How does representation construct knowledge?
- Block 4: How will new media technologies transform knowledge and education?
- Block 5: workshop project (Wiki workshop)
- Block 6: Does the Anthropocene have a future?

This means that the module does not introduce students to educational subjects as such, but rather encourages students to think critically about records and information: objects, evidence and interpretation: and stories, narratives and meaning. Students – in the sense set out by Vivianne Burr (2003) – are encouraged to ‘take a critical stance toward our taken-for-granted ways of understanding the world, including ourselves’. This means, students are encouraged to see science as a ‘set of practices’ – following Stuart Hall’s (1997) approach to culture. As Hall (1997, p. 2) in relation to culture states: ‘Primarily, culture is concerned with the production and exchange of meanings - the “giving and taking of meaning” – between the members of a society or group’. Equally science – and science education – could be seen as a driving force for the creation and representation of our knowledge about the world we live in and ourselves.

It is in this context that students are introduced to the notion of discourse, which we define in a Foucauldian sense as ‘...a group of statements which provide the language for talking – a way of representing the knowledge about – a particular topic at a particular historical moment’ (Hall 1992 cited in Hall 2004, p. 72). This leads to the argument that knowledge might not be absolute but rather provisional and that what is presented in a curriculum represents selections from the knowledge available in any particular culture at a given point in time. The module therefore moves beyond seeing science as a pure subject to be mastered by prospective educators; rather, it focuses on the subject of science itself to open up questions encouraging students to think more holistically about knowledge creation and dissemination. Crucially, this approach envisages science education as needing to be creative and innovative – and challenging current perceptions and approaches of students as well as teachers.

### **Teaching Practice: Introducing the Notion of Discourse**

Introducing students to Foucault’s work and the notion of discourse carries its challenges, especially as most students on the module are unfamiliar with the work of social theorists – and theoretical concepts such as power and knowledge. We tackle this problem by using a constructivist approach to getting students to think about the world they are living in. First, we encourage students to think about the world around them: ‘How do humans shape the world around them? And how are they shaped the world around them?’. By doing that we hope to move them from an objectivist viewpoint to a positioning whereby they realize that culture is not a set of things, but ‘... concerned with the production and exchange of meaning – “the giving and taking of meaning” – between the members of a society or a group’ (Hall, 1997, p. 2).

However, early on we try move our students beyond a “simple reflection” on their experiences and worldview by asking them: ‘Why is it important to think about these things?’, a kind of meta-reflection on our sessions. We argue with our students that it is important to think about the world they are living in and their perception because it consists of concepts and ideas that shape what they “believe” and how they interact with the world

around them. In this context we argue that ‘... language is the privileged medium in which we “make sense” of things, in which meaning is produced and exchanged’ (Hall, 1997, p. 1). This leads us to the idea that language acts as a representational system; it stands for or represents to other people our ideas and feelings. This means, following a constructivist tradition, we do not simply perceive the world as it is, but we are “making sense” of our perceptions with the help of language.

To bridge the gap between the idea of language as a means to interpret and re-present our lived experience, and discourse as a theoretical tool to reflect on science education, we use the idea of ‘knowledge technologies’. Knowledge technologies, as we use and understand them in our teaching, are assemblages in the sense of Deleuze and Guattari (1987), which can extend our understanding of the world and how we come to learn about the world. Some of these, which are explored and developed in the module, are: time, mathematics, the printed word and maps and cartography – and also digital technologies, including social media, and scientific ways of looking at the world such as biology, chemistry and physics. In reference to science, we invite a science communicator into our classroom to illustrate to students how scientific ideas and their perception change over time – and also how these ideas shape our worldview.

Further, we look with our students at how scientific ideas and discoveries are communicated to the general public at a particular point in time. In this context, we also explore how schools tackle scientific ideas and discoveries. As an example we look at the idea of evolution and its representation in educational policies. For example, the new UK National Curriculum (Department for Education, December 2014) states:

‘Pupils should be taught to:

- recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago
- recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents
- identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution’.

With the help of these examples we introduce our students to the notion of discourse, the idea that ‘...a group of statements which provide the language for talking a way of representing the knowledge about a particular topic at a particular historical moment’ (Hall, 1992, p. 291). We argue that discourse, in the sense of Foucault, is not purely a mode of speech that presupposes a founding subject. It provides the very ‘...space of emergence determined the possibilities for speech and speaking subjects’ (Clifford, 2001, p. 182); in doing this discourse surpasses the individual and the structures but instead infiltrates itself, becoming structured and structuring. In this context science and science education can be seen as systems of representation that generate “knowledge” and “truth” – fluid and versatile, but nevertheless bound to existing systems of knowledge and their underlying power relations. Hence, we tell our students, it is important that we do not base science education on the teaching of facts and figures, but rather embrace the idea of science as a discourse that shapes our understanding of the world and ourselves.

## **Conclusion and Recommendations**

In this paper, by looking at science in the context of an Education Studies module, we, the authors of this paper, have evaluated practically the objectives and some of the new developments in science education curricula, and theoretically explored the possible contributions of using the concept of discourse to approach the emergence and prevalence of scientific systems of knowledge. We have argued that these scientific knowledge-systems are producers of reality and do not occur disentangled from power relations. Following a Foucauldian perspective we have also alluded to how these discourse-based producers of reality are not inherently producing truths, but rather, effects of truths. As a result of these explorations we argued that the education of prospective educators needs to move beyond fact-bounded pedagogy and approximate towards a more constructivist understanding of the subject area of science.

In practice this means to encouraging students to de-essentialize curricula in order to become holistic pedagogues: to “provisionalize” knowledge in order to be critically aware of its effects: and to understand the changeable, shifting, fluctuating and dynamic nature of societies. These myriad effects, changes and moves – discussed within the module – occur as part of a wider culturally, technologically and ideologically changing paradigm. The approach we have taken with our students is to question critically traditional concepts and

pedagogies, by presenting to them conceptual tools such as discourse, power relations and constructivism that afford them the opportunity to reflect on these macro and micro level topics.

Consequently, as Wellington (2005, p. 107) states: ‘The essential bridge that needs to be built [is] between the world of experiences (the phenomenal) and the world of explanation (the conceptual or theoretical)...’. We propose that to bridge this gap students need to be given the opportunity to deal with metaphor, theory and the abstract but at the same time the concrete, experiential and practical, not in an atomized and disjointed manner but rather by understanding them as an interconnected, inseparable and unfolding continuum.

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