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Title Paper 1: The nature of the epistemic differences between chemistry knowledge and knowledge in chemical engineering

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Abstract

The paper provides a conceptual background to general disciplinary differences in the epistemic properties of knowledge in the sciences and engineering sciences. These differences are based on findings from a case study on undergraduate curriculum knowledge in thermodynamics in the pure and engineering sciences. The conceptual nature of the paper allows scope to delineate analytical and methodological generalisability of the findings. The epistemic differences will be used to speculate on the impact of the nature of the knowledge for the relationships students need to develop with disciplinary knowledge across their academic careers as neophyte scientists and engineers. Furthermore, the paper explores aspects of interviews with first year lecturers conducted at the four university sites as these relate to the way lecturers believe students change in the course of their studies.

Extended Abstract

The project this paper speaks to is a longitudinal study of relations between disciplinary knowledge, the undergraduate curriculum and student agency as these are surfaced in two related STEM subject fields, that of chemistry and chemical engineering, at four different universities in the UK and South Africa. One of the major concerns of the project is to gain an understanding of the way students develop a sense of identity as neophyte discipline specialists in the course of their academic careers. We propose that this shaping of identity takes place, as least in part, as a result of students' interaction with discipline-specific knowledge as they negotiate their way through the curriculum.

Society draws distinctions between science and engineering, often in intuitive and vague ways: even though there is recognition of close relations between fields such as engineering and the pure sciences, chemists and chemical engineers take on different societal roles. These different roles are reflected in the way universities and colleges are organised where science and engineering students are educated in separate departments and faculties in institutions of higher education. There is therefore a general understanding that disciplinary differences do exist and are significant. It seems reasonable then to suggest that differences in epistemic properties of the knowledge will potentially have differential impact on the transformation of student identities. But what is the nature of the disciplinary knowledge differences between the pure sciences, such as chemistry, and the engineering sciences, such as chemical engineering?

This paper makes two contributions to the symposium and to a better understanding of the concern of the broad project with student identity transformation. First, there is a conceptual contribution in the discussion of case study findings on the nature of epistemic differences between knowledge in the pure and engineering sciences. Secondly, this is supported by a consideration of early empirical data from interviews with first year chemistry and chemical engineering lecturers.

A case study on the epistemic characteristics of thermodynamics curriculum knowledge conducted across four disciplinary fields, two in the pure sciences and two in engineering sciences, revealed substantial differences in the nature of disciplinary knowledge (Smit, 2017). The same basic content knowledge, the first and second laws of thermodynamics, was analysed in relation to a theoretical instrument developed from the sociology of education and the applied philosophies of science and engineering science. Bernstein's (2000) categorisation of knowledge in terms of regions and singulars provided a helpful starting point for contrasting engineering and science knowledge: singulars, such as chemistry and physics are characterised by strong disciplinary boundary maintenance, whereas regions, like chemical and mechanical engineering, have weaker disciplinary boundaries. This is the result of the professional and occupational knowledge structures' Janus-faced orientation towards both the singulars and fields of practice. Ultimately though, Bernstein's notion of singulars and regions remains only partially developed (Beck & Young, 2005), and is not fine-grained enough to explore the rich differences observed in the curriculum knowledge of the contiguous subject fields.

Instead, taking broad teleological considerations of the disciplinary fields as the starting point, the philosophical concepts of specialisation, idealisation (Morgan & Morrison, 1999; Weisberg, 2007; Van Fraassen, 2010) and normativity (Dancy, 2006; Franssen, 2009; Radder, 2009) were developed into a theoretical instrument for analysing disciplinary knowledge. Applying this to the data, engineering science knowledge is found to emphasise particulars, rather than universals, has stronger normative aspects, and employs a limited form of idealisation in its commitment to physical realisability of artefacts. Knowledge in the sciences, on the other hand, is more universal, normativity is incidental and idealisation is used extensively in its drive towards abstract theorisation.

How might the case study findings relate to the Knowledge, Curriculum and Student Agency project? Returning to the proposition that disciplinary knowledge might play a role in the formation of students as novice discipline specialists by the end of their academic career, the case study provides some indication of what might be important for developing a "specialised disposition" (Muller & Young, 2014) for students as they progress through the curriculum. In addition to this, aspects of interviews conducted at all four university sites with first year lecturers in 2017 were analysed. In particular lecturers' beliefs about how first year students differ from final year students were explored in relation to the nature of disciplinary knowledge. Taken together, these perspectives on the nature of epistemic difference and lecturer observations on how first year students need to change, give insight into a central concern of the project on Knowledge, Curriculum and Student Agency.

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