Knowledge matters: interrogating the curriculum debate in engineering using the sociology of knowledge

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Abstract

A growing field of research applies perspectives from the sociology of knowledge to analyse curriculum in particular disciplinary contexts in higher education. This article considers recent calls in engineering education for reform of the curriculum, centred on a debate between project-based and problem-based (PBL) models. A Bernsteinian analysis shows that moves towards these kind of curricula would involve a weakening of both classification and framing, particularly in the case of PBL. Although these proposals tend to be motivated by a desire to improve the quality of student learning, it is suggested that in implementation the more radical forms of PBL could have implications for student learning that are quite the opposite to what is intended. Furthermore, there are likely demands on academic identity that might not be possible to accomplish in the present situational logic of the academy. Curricula are needed that recognise the boundedness of specialised knowledge and pedagogical practices that can assist students to navigate these boundaries: project-based may well be a more sensible curriculum response in engineering education than PBL.

Introduction

> . . . the curriculum question has become a central concern in engineering education.
> (Ruprecht, 2000, p.360)

Curriculum is a hotly debated topic in education. Everyone has an opinion on what should be done to 'fix' the problem, be it literacy levels in the primary school, the ability of graduates to function in the workplace, or whatever. From the perspective of sociology of knowledge, this clamouring of voices is hardly surprising, given that curriculum is the key site in education where power operates. A crucial contribution of this field, in particular in the work of British sociologist Basil Bernstein, has been to provide detailed descriptions of the mechanisms whereby curriculum tends to operate to secure the interests of dominant groups in society (Bernstein, 2000). Significantly, this work has started to deliver important insights into key aspects of curriculum that are essential for fostering the academic success of traditionally marginalised groups (Hoadley, 2006). A striking finding has been that ‘progressive’ curricular arrangements, intended to deliver greater social justice and equality, in practice can actually serve to further disadvantage precisely those groups of students that they seek to empower (Muller, 1998).

Work in the sociology of knowledge has tended largely to focus on schooling, but more recently there has been a growing interest in applying these theoretical tools to the context of curriculum in higher education. At the disciplinary level, this work involves explorations of:

1. How curriculum knowledge gets constructed.
2. The constraints that the knowledge structure of the discipline places on the curriculum, and
3. The range of identities that the curriculum makes available for students (Luckett, 2010).

Studies have been conducted so far in the disciplinary areas of history (Shay, 2011), sociology (Luckett, 2009) and design (Carvalho, Dong and Maton, 2009). This article aims to contribute to this growing body of knowledge by a preliminary exploration of curriculum as it plays out in the field of engineering education.

Engineering education is located at the heteronomous pole of the field of higher education, where external influences, particularly those from professional bodies and industrial concerns, play a significant role in determining what gets valued (Maton, 2005). These external influences provide ongoing fuel to the curriculum debate in engineering education, largely focused on a concern about what graduates can actually ‘do’ when they enter the world of work, and generally issuing in curricular proposals which suggest a stronger focus on developing skills and engaging with ‘real world’ problems. A study of knowledge and curriculum in this field thus has potential value for other disciplinary areas which also face outwards towards the world of practice, what Bernstein (2000) terms ‘regions’.

Much of the discussion in the engineering education literature on possible curriculum models centres firstly on a set of claims around their intentions and secondly around whether they ‘work’. And with regard to the intellectual resources at hand to make these judgements, it is frequently stated that the tools of engineering are appropriate to the task (cf. Froyd and Ohland, 2005;

Rompelman and De Graaff, 2006). This article suggests that the tools of the sociology of knowledge are maybe more suited to interrogating curriculum proposals than those of engineering design, and it engages with these debates through outlining and then marshalling these tools.

Locating the curriculum debate in engineering education

Engineering curricula in most parts of the world are directly controlled by professional engineering bodies through regular audits. In South Africa, this body is the Engineering Council of South Africa, a statutory body which runs a delicate line between the interests of capital and those of the state. Moreover, in its interaction with the global professional community, it has an interest in ensuring that South African engineering graduates can get professional recognition in the key countries of the first world. Thus arose the most noticeable impact on engineering curricula in recent times in the form of 'outcomes-based' accreditation which was introduced initially in the revised US ABET criteria (Accreditation Board for Engineering and Technology (ABET), 2000), and thereafter in the accreditation bodies of partner bodies in the Washington Accord, a multinational agreement offering mutual recognition of engineering degrees including the USA, UK, Australasia, Hong Kong and South Africa.

The shift to outcomes-based accreditation falls in line with much current popular thinking in higher education and in society in general which asks questions about what graduates can 'do' rather than more traditional perspectives which centre on what graduates 'know'. This also matches the current demand from the cash-strapped industrial sector which has started to demand that graduates can deliver value from their first day in the workplace. The common refrain seems to be that the traditional engineering curriculum does not sufficiently prepare graduates for functioning in the workplace, as stridently expressed in the following quote:

> In recent years studies have been conducted in many countries to determine the technical and personal abilities required of engineers by today's industry. These studies have indicated some key concerns. Today's engineering graduates need to have strong communication and teamwork skills, but they don't. They need to have a broader perspective of the issues that concern their profession such as social, environmental and economic issues, but they haven't. Finally, they are graduating with good knowledge of fundamental engineering

> science and computer literacy, but they don't know how to apply that in practice (Mills and Treagust, 2003, p.3).

The urgent tone noted above is reflected across much of the current discussion on curriculum in engineering education. There is an assumption that the curriculum is not delivering what is needed by society and that substantial change is needed in order to do so. For example, note the following statement from Jackie Walkington, an Australian academic who has published widely in engineering curriculum development:

> Today's faculty leaders and managers in higher education can no longer facilitate curriculum development as they have in the past. Strategic planning and operational decisions must reflect the changing nature of society, the world of work and education. This does not mean just to react to changes in other places, but to be proactive in predicting and responding to future needs of all stakeholders in the higher education environment (Walkington, 2002, p.133).

In this climate of heightened urgency for change has arisen a substantial debate on what form the curriculum should take. Key positions on curriculum are outlined in the following section.

New curriculum models in engineering education

The traditional engineering curriculum involves an exclusive focus on basic science courses at the start of the programme, with the subsequent introduction of engineering science courses alongside more advanced science courses. Towards the final years of the degree, at the point where students have mostly grasped all of the advanced engineering science, there is the introduction of project work, focusing particularly on engineering design. One innovation that has been implemented in some places over the last few decades is the introduction of engineering science courses from first year (see, for example, Reed and Sass, 2000). In some cases these introductory engineering courses involve significant project work.

The current debate on curriculum in engineering education centres on what role project work should play across the whole curriculum, not just at the first year introductory level and in the capstone design courses. The most prominent labels for these new curriculum models are those under the banners of *problem-based* and *project-based* learning. Although there is further terminology which provides variations on these themes (see, for example, Lehmann, Christensen, Du and Thrane, 2008; Mills and Treagust, 2003;

Perrenet, Bouhuijs and Smits, 2000), for the purposes of this article it will suffice to focus on the two key models. Problem-based learning (PBL) originated in medical education and in its pure form it rests on an assumption that students will learn best in 'authentic' learning contexts where they are tackling real world problems and locating the necessary knowledge as they need it. Project-based learning typically refers to course modes where students are required to apply the knowledge that they have been taught; the focus here is on the application of new knowledge through the problem. This is of course the mode of teaching that has been long used in engineering education in the final year design project course, as mentioned above. Problem-based learning is a much more radical move where knowledge is only accessed as and when needed by the project.

Kirschner, Sweller and Clark (2006) use the label 'minimally guided approach' to describe problem-based learning together with related curriculum modes that have been fashionable across the twentieth century, particularly in school science, including inquiry learning, discovery learning and experiential learning. The most widespread application of PBL in engineering curriculum is most probably at Aalborg University in Denmark, a whole university where 75 per cent of the courses are offered in a project-based format. Lehmann and colleagues (2008) argue that the problem-oriented and project-based learning paradigm that they utilise in their engineering programmes is best placed for being able to incorporate problems around sustainable development across the curriculum.

The debate on curriculum in engineering education is thus largely centred around PBL and its variants. One of the strongest statements on the relevance of PBL to engineering education comes from Veldman and colleagues (2008) who in the title of their recent article state provocatively "Can engineering education in South Africa afford to avoid problem-based learning as a didactic approach?". With a departure point centred on outcomes-based education, they claim that PBL has the best chance of achieving curriculum alignment with the learning outcomes. They also claim that PBL is well placed to facilitate development of what they term 'non-subject-related skills'. Others are somewhat more guarded. Two recent review papers on the application of PBL to engineering education (Mills and Treagust, 2003; Perrenet, Bouhuijs and Smits, 2000) suggest that it is not appropriate as a model for overall curriculum development, but is rather best applied in specific courses.

It would thus appear that most commentators are in agreement that project work should form a significant part of the engineering curriculum, and that this needs to run in a sustained manner throughout the curriculum rather than appearing only in the final year as in the traditional capstone design course, or even additionally in the first year as an introduction to engineering. The debate centres on what is more suitable: the highly publicised PBL model which uses problems rather than traditional knowledge categorisations to structure the curriculum, or the more traditional project-based mode which leaves the traditional organisation of knowledge areas intact and couples these with projects to show applications of this knowledge.

Two exemplars of innovative curricula in chemical engineering

To provide some empirical illustration of the positions in this debate, two undergraduate chemical engineering curricula will be considered here: a well-established project-based curriculum at Imperial College in the UK (Perkins, 2002), and a recent curriculum innovation at University of Sydney in Australia which describes itself as problem-based (Barton, Abbas, Cohen, Gomes, Harris, Holt and White, 2006). Both universities are highly selective and take in high performing students from 13 years of schooling, offering a four-year chemical engineering degree which leads to an accredited masters qualification in engineering.

At Imperial College the programme involves chemical engineering from the first year of study. There is an intensive use of project work running throughout the curriculum. The timetable reflects this structure, with lectures and tutorials in the mornings covering standard chemical engineering subjects (including mathematics and chemistry) as well as management and humanities, and design-oriented project work taking place on all except one ‘free’ afternoon. To progress to the following year, students need to pass with 40 per cent in both the (largely project-based) course work and the final examinations. ‘Mastery’ assessment is a key part of the assessment, whereby students need to demonstrate 80 per cent proficiency in an integrative examination paper focusing on the essentials of chemical engineering. The last two years of the programme offer a range of different directions for students depending on the interests they have developed. Some opt for a year abroad, while others take elective directions based on particular specialisations.

The University of Sydney recently undertook a complete rebuild of its undergraduate chemical engineering curriculum, in response to a perception that its graduates lacked the competencies required in the workplace, especially an 'adaptive flexibility' needed as so many of them no longer went to the traditional process industries. It was felt that the semesterised curriculum with knowledge in different compartments was a key contributor to this problem, and thus a complete overhaul was embarked upon. The new curriculum is structured around a problem-based learning approach, emphasising competency attainment, and aiming for strong horizontal (within a semester) and vertical (across semesters) integration. Courses were designed that fitted into the following categories, with each semester containing all these course types:

(a) core principles (presenting fundamental chemical engineering concepts)

(b) enabling technology (tools, often computer-based, needed to solve problems)

(c) engineering practice (Core Practice courses) and

(d) electives (either specialised or broadening).

All of these courses are offered in PBL mode, where learning takes place through engagement with real world problems and students need to acquire the necessary knowledge under the guidance of a teacher. The course structures do not reflect the traditional chemical engineering science subjects organised around particular unit operations e.g. reactor engineering or separation processes. There are no dedicated mathematics courses after the first year; any mathematics needed is taught in the context of the relevant chemical engineering course. An important aspect of the delivery of the new curriculum is that each course is taught by a team of academics. There is a 'semester supervisor' in each year who focuses on obtaining the necessary horizontal integration across the courses.

The first year of the programme is run in conjunction with other engineering programmes in the Faculty, and many students actually enter through a flexible route where they only choose their programme at the end of the first year. In years two and three of the programme, assessment of the core and enabling courses is via 'competency' assessment (similar to the 'mastery assessment' at Imperial College) and students are simply awarded pass/fail results. Assessment of competency is through a range of course assessments as well as the final examination. Because of the commitment to tight integration in the programme, student progression through the programme is largely ‘plug flow’ in nature, with only one uncompleted course being able to be carried into a subsequent year. Supplementary oral examinations are conducted with borderline candidates in order to keep as many students as possible in the planned curriculum.

What has been described here are two curriculum models that have sought to depart from the traditional engineering curriculum. In the project-based curriculum at Imperial College there is a retention of the traditional structure for the presentation of basic science and engineering science knowledge (through traditional subject structures and lecture/tutorial modes) with the inclusion of a strand of project-based work which runs alongside throughout the curriculum. The revised curriculum at the University of Sydney demonstrates the problem-based curriculum model, where the traditional subject structure of the engineering curriculum is largely abandoned, and knowledge is marshalled as needed when tackling a set of carefully designed problems.

This article now turns to an explication of key tools from the sociology of knowledge in the context of engineering knowledge and curriculum, in order to build a base from which to interrogate these models of curriculum innovation in engineering education.

Using Bernstein’s sociology of knowledge

Implicitly underpinning of the work of Basil Bernstein, more recently formulated as a distinct tradition, is a social realist perspective on knowledge. Young and Muller (2010) encapsulate this as “an emphasis on the irreducible *differentiatedness* of knowledge” (their emphasis). They continue:

> Knowledge is structured, in part independently of how we acquire it, and knowledge fields differ in their internal coherence, their principles of cohesion, and their procedures for producing new knowledge (Young and Muller, 2010, p.15)

Commonsense discussions of curriculum frequently conflate curriculum knowledge with disciplinary knowledge: these are seen to be one and the same thing. There is often also a further conflation of curriculum and pedagogy. Bernstein’s ‘pedagogic device’ recognises that these are distinct forms of knowledge each associated with a particular field of play: disciplinary knowledge functions in the field of production (in the arena of research and scholarship), curriculum knowledge functions in the field of recontextualisation and is manifested in curriculum documents etc. and pedagogy functions in the field of reproduction. In considering curriculum, a significant area for investigation is the process of 'recontextualisation' where there is a selection and a reforming of disciplinary knowledge to transform it into curriculum. Importantly, as knowledge moves between one field and another, a 'discursive gap' exists where power interests are at play (Bernstein, 2000).

Nonetheless, recognising the emergent powers of knowledge it is clear that the underlying disciplinary knowledge structure will always place some limits on the form that the curriculum can take (Muller, 2009). As Maton (2009, p.55) writes, ". . . knowledge has its own causal powers and tendencies. That is, different structurings of knowledge possess different affordances – they lend themselves more to certain forms of pedagogy, evaluation, identity, change over time, and so forth, than others." Thus, a starting point for interrogating curriculum in a disciplinary area requires an examination of the discipline as represented in the field of production.

As noted earlier, in Bernstein's terms, engineering can be described as a 'region', lying at "the interface between the field of the production of knowledge and any field of practice" (Bernstein, 2000, p.9). The field of practice of engineering has a long-standing tradition of knowledge based on 'what works', the so-called 'heuristics' or 'rules of thumb'. For example, in chemical engineering it is known from practice that it is economically optimal for the velocity of a liquid in a pipe to be between 1 and 3 metres per second. For the purposes of this paper we will call this 'engineering practice knowledge'. At the time that engineering disciplines established themselves as legitimate members of the academy (Noble, 1977), there was a pulling away from the field of practice (on the shopfloor) towards the field of production (in the academy) to establish the 'engineering sciences', which build on a set of recontextualised 'singulars'. Thus, for example, 'chemical engineering science' is a scientific field of its own which uses advanced mathematics, physics and chemistry. This field involves, for example, a complicated set of differential equations which describe the mass transfer of substances through a particular region in space. In Bernstein's (2000) terms, engineering science knowledge (like other science knowledge) is a "hierarchical knowledge structure", which "attempts to create very general propositions and theories, which integrate knowledge at lower levels" (Bernstein, 2000, p.161). Engineering science knowledge is of course the engineering knowledge which is valorised in the academy, compared to engineering practice knowledge, which some commentators suggest is more akin to an art than a science (Winkelman, 2006), although Gamble's (2006) analysis of knowledge in the field of practice suggests that it too is underpinned by principled forms of knowledge.

In the recontextualising process there is a contestation between these two different forms of engineering knowledge as to the prominence that they enjoy in the curriculum. Given that it was the engineering sciences that established themselves in the academy, at least in part in a move away from engineering practice knowledge, it is maybe not surprising that the engineering sciences strongly dominate engineering curricula around the world. However, the professional voices, most notably through the mechanism of accreditation, have managed to retain an emphasis on practice through the inclusion of design courses, particularly at the final year level, which involve real world problems where students are required to engage with contextual information and apply heuristics and other methods of approximation where appropriate.

The dominance of engineering science as the basis for engineering curriculum is currently under further contestation from another angle. There are those who argue that there are other knowledge areas, for example politics, economics and social science, which need to be incorporated into engineering for it to be able to fulfil its mission of responding to human needs. Bernstein has shown how the social sciences tend to have a 'horizontal' knowledge structure where parallel perspectives are set up against each other, rather than subsuming subordinate concepts into a higher structure. The incorporation of two different kinds of knowledge structures into one curriculum thus poses an interesting challenge to engineering educators.

An important contribution of Bernstein's framework for analysing curriculum is the analytical construct of 'classification' which refers to the boundaries between categories of knowledge. It is in the legitimation of these boundaries that power is exerted (Bernstein, 2000). Traditional engineering curricula exhibit strong classification, especially at the lower levels involving exposure to a range of 'singulars', but the final year design project mentioned above involves a weakening of classification as students are expected to integrate engineering science knowledge from different areas, as well as incorporate engineering practice knowledge where appropriate (Kotta, 2008). Alongside classification Bernstein identifies 'framing', referring to matters such as selection of content, sequencing and pacing, as the key means whereby control is exercised, socialising individuals into particular identity spaces. From this perspective one can see that traditional engineering curricula which are largely prescribed and content-loaded tend to be strongly framed. Bernstein conceptualises such a curriculum, involving strong classification and framing, as a ‘collection code’. This concept is intended as an ‘ideal type’ but nonetheless versions of it can be recognised, for example in the early years of the traditional engineering curriculum.

Both the project-based and problem-based models of curriculum outlined above tend to involve a weakening of both classification and framing across the curriculum, more radical and widespread in PBL. As seen in the curriculum from the University of Sydney, the organising principles for the PBL-type curriculum are based on real world contexts, not on the abstract conceptual organisers of the discipline. Selection of material tends to be less fixed, and depends on the particular problem at hand. Pacing of learning is more at the level of individual students and their needs. This form of curriculum relates to Bernstein’s other ideal type, the ‘integrated code’.

Bernstein’s concepts of classification and framing have been more recently extended by Maton to apply not only to knowledge structures but also to what are termed ‘knower’ structures (Maton, 2007). Knowledge structures speak to the relationship between the knowledge and the object of knowledge, while knower structures refer to that between the knower and the knowledge. Just as each curriculum will have an implicit (or explicit) knowledge structure, there is always a knower structure, i.e. a notion of what the ideal knower should be. However, knower structures can also be weakly or strongly framed and classified, just like knowledge structures. Maton suggests a further conceptualisation of these as the strength or weakness of

1. the epistemic relation – classification and framing of the knowledge structure and
2. the social relation – classification and framing of the knower structure.

Traditional curricula in engineering, while certainly embodying an ideal ‘engineer’ tend to place relatively little emphasis on dispositions and attitudes of the student. Thus an increased focus on personal growth, implicit in most curriculum models which involve more project work, does, I argue here, imply a strengthening of what Maton terms the ‘social relation’ underlying the knowledge structure. This is not to mean that we necessarily return to the ‘cultured gentleman’ as the ideal knower of the traditional humanities curriculum, but this would nonetheless imply an increased exercise of power and control on the student’s dispositions at the graduate outcome stage.
It is important to realise that Bernstein’s theory does not immediately place a

normative value on strong or weak classification or indeed on strong or weak framing. However, he suggests that if there are proposed changes in the modalities of classification or framing it will always be important to ask two key questions:

1. *Which group is responsible for initiating the change?* (dominant or dominated)
2. *If values are weakening, what values remain strong?*

(Bernstein, 2000, p.15)

With regard to the first question, Bernstein suggested that if a dominant group is requiring change this will be a rather different situation to if a dominated group is doing so. The former are likely to favour strategies that conserve the status quo, while the latter will favour subversive strategies. Considering calls for reform in engineering education, we need to examine whether the pressure for change is from within (autonomous) or without (heteronomous) the field. The curriculum debate outlined earlier is largely being conducted by engineering academics with an interest in teaching and learning. Slowly there is a growing interest in a scholarly engagement with these issues and a growing recognition of the value of education research, but these are early days and much of the debate proceeds with little reference to the education literature. Thus, Radcliffe and Jolly (2003) note the prevalence of the 'lone enthusiast' in engineering education, who are often able to infect at least a few other colleagues with their enthusiasm for a particular initiative. With regard to the current focus towards an inclusion of more project work, these resonate with the power interests external to the academy, notably, industry and professional bodies, who are increasingly focused on 'what graduates can do'. Furthermore, with the escalation of focus on teaching and learning in the academy, these calls for curriculum renewal are also in a favourable position with regard to internal power structures.

But whose interests do they ultimately serve? At this point we need to focus on those invisible people who generally move with quiet perseverance through our curriculum structures: the students. The traditional university set itself up to be able to work with an elite group of students from middle class homes and high quality schooling; the massified university of the post-war era is still struggling to come to terms with the fact that the students have changed. Traditional curriculum structures in engineering education have been shown to be insufficiently responsive to where students are coming from, but it is not automatically so that reformed curricula with different degrees of inclusion of project work will necessarily meet the goals that they have set for themselves in the context of the real and diverse student bodies that enter engineering studies in the 21st century.

Implications of new curriculum proposals for student learning

In discussing student learning Maton (2009) makes the distinction between ‘cumulative learning’, where new understandings are built on prior knowledge or ‘segmented learning’ where new ideas get accumulated but not subsumed into existing understandings. This is of course a central concern in all of learning research and practice. It is fairly clear that curriculum design will play a crucial role in either constraining or enabling cumulative learning.

In an illustrative analysis of two curricula contexts which emphasise ‘authentic learning’, Maton (2009) shows that although these contexts had expectations that students develop abstract understandings of the knowledge areas, because of their teaching environment which involved minimal guidance and only explanations of the task at hand, many students did not manage to fulfil these expectations: their new ideas remained rooted in the context of the problem. Maton argues that these contexts in fact “set up many students to underachieve as it is the ability to generalise and abstract that is rewarded in such tasks” (p. 51). Furthermore, it is those students with less advantaged backgrounds who are particularly disadvantaged by this kind of curricula arrangement which requires you to utilise tacit knowledge often of the sort that comes with a particular family background.

This is therefore the first caution for radical (PBL) curriculum reform in engineering: that in making less explicit the boundedness of the specialised knowledge that needs to be acquired, that one might particular disadvantage those very students one is intending to help. In this regard Muller (2007) offers the following observation:

> . . .understanding hierarchy in discourse is a necessary prelude to combating it in society.
> (Muller, 2007, p. 2)

A dangerous misconception of many progressive education agendas has been that the way to make academic knowledge more accessible is to dissolve the boundaries that exist in traditional curricula. At the heart of Bernstein’s conceptualisation of learning are the concepts of ‘recognition’ and 'realisation' rules that focus directly on the central significance of recognising and navigating boundaries. Young and Muller state this clearly:

> By emphasising the social differentiation of both knowledge and institutions, social realist approaches challenge the widely shared assumption that boundaries are always barriers to be overcome rather than also conditions for innovation and the production and acquisition of new knowledge. As Bernstein (2000) argues, boundaries play an important role in creating learner identities and are thus the conditions for acquiring 'powerful knowledge' as well as being barriers to learning.
>
> (Young and Muller, 2010, p.16)

Above it was also noted that all of these innovative curricula involving a greater emphasis on project work might involve a strengthening of the social relation. This development could also have implications for student success and progression, especially those not from middle class backgrounds with the kind of cultural capital that can predispose one to pick up these subtle demands. This will be a challenge to pedagogy and assessment, not to say that it should not be taken on, but it should not be taken on lightly.

Student identities and academic identities are closed tied together in a 'necessary' relation in that the possibilities for student agency are constrained by the practices of academics (Archer, 1996). Thus, in interrogating new proposals for curriculum in engineering education, we also need to look at the potential impact that these could have on academics.

Implications of new curriculum proposals for academic identities

Kotta's (2011) investigation of student learning in the context of a relatively traditional curriculum points to the difficulty that engineering educators have in collaborating sufficiently to deliver just a portion of curriculum (senior design) that requires working in a more 'integrated code' manner. When the pedagogy failed, it was the students from more disadvantaged education backgrounds that suffered the most. Kotta traces the logic of the academic practices and identities to the values at play in the institution and provides a warning for engineer educators who think a shift to more project work will be easy to accomplish.

Bernstein points out that in a 'collection code' curriculum, because staff are differently specialised and linked together in a hierarchical system, very little collaboration is needed or is practised. An 'integrated code' system makes very different demands of staff: of necessity they need to collaborate since the organisational structure will require this. Bernstein issues a caution, noting that a model like this is ‘highly vulnerable’ because it will be open to a range of influences from the outside. Furthermore the staff will need to form a strong social network if it is to be at all successful; simply ‘no easy activity’ (p. 11).

Muller (2009) also notes that because of the hierarchical knowledge structures in the ‘hard’ disciplines, there is little contention over what’s in the undergraduate curriculum, and thus academics spend relatively little time on their undergraduate teaching (compared to those in the ‘soft’ disciplines). This continues into the postgraduate arena where again, relative to those in ‘soft’ disciplines, less time is spent on supervision, such that research output (and/or industry collaboration) can be prioritised. Thus it can be seen that the structuring of knowledge has a structuring effect on the social relations in the field.

Thus it is clear that a significant curriculum restructure towards a more integrated code has huge implications for academic identity and academic time. Importantly, if these relations remain unchanged, the integrated code curriculum will simply be a disaster. ‘What matters’ in the field of higher education will always be a matter for contestation, but one is unlikely to quickly see a radical shift of valuing.

Conclusion

> Our purpose is not to defend a conservative position or to look back to a ‘golden past’; far from it. It is to confront the view (which we share) that access to powerful knowledge is a right for all not just the few, with a theory of ‘powerful knowledge’ and how it is acquired and the crucial role of formal education in that process.
>
> (Young and Muller, 2010, p.24)

This article set out to interrogate curriculum reform proposals that are currently on offer in engineering education, using tools from the sociology of knowledge. The debate in engineering education centres on concerns for what graduates can do when they enter the workplace. A key curriculum question is which of problem-based learning, with a reorganisation of the curriculum around real world problems, or project-based learning, which retains a traditional organisation of the curriculum, is more suitable. An analysis of these positions using Bernstein’s tools of classification and framing together with Maton’s elaboration thereof, shows that although both of these models involve a strengthening of the social relation (a greater exercise of control over legitimate student identities), the problem-based mode also involves a weakening of the epistemic relation (a blurring of knowledge boundaries).

For an analysis of any curriculum reform from a sociology of knowledge perspective it is important to analyse which groups are calling for the change. Although as noted above there are significant external pressures on the engineering curriculum, it might also be noted that it is largely engineering educators with a passion for teaching and learning who are proposing particular curriculum models. The intentions are good. However, the analysis moves to a consideration of the likely implications of such curriculum modes for student learning, particularly in the context of a massified higher education system which needs to cater beyond the needs of the elite. Preliminary research suggests that curricula with weakened boundaries such as those represented by the more radical PBL versions might indeed have outcomes quite contrary to those intended, with particular difficulties posed for students from weaker academic backgrounds. Furthermore, there is a serious likelihood that in the current situational logic in the academy, academics will lack the collaborative practices to properly 'pull off' such a curriculum move. This suggests a further detrimental effect on student learning.

At this point it is worth noting the important distinction between curriculum and pedagogy which comes with a social realist perspective (Young and Muller, 2010). Good teaching in engineering has always involved pedagogies which help students make the link between engineering science knowledge and the real world 'out there'. However, this is not the same as making the real world the organising principle for the curriculum, as is the case in the problem-based curriculum. In conclusion it is therefore suggested that what is needed is a curriculum which recognises the boundedness of both engineering science and engineering practice knowledge, and which helps students to navigate between these terrains. In this light, it would appear that the more cautious project-based curriculum model has a better chance of meeting the needs of all students, both in the realm of curriculum, but also, significantly, in pedagogy and assessment.

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