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Bringing Engineering Education to Life – An Empirical Approach

Abstract

This paper focuses upon the argument that the role played by the Engineering Profession within today's society has changed markedly over the past 10 years. From the Industrial Revolution until recently, Engineering played a significant part in society, providing scientific and technological linkages between industry and day-to-day life. This somewhat understated, yet crucial role has changed recently in that Engineering has moved from providing the foundations for contemporary life to leading societal change and becoming one of the key driver's of future social development. Yet at a time when society's demand on Engineering are increasing, it appears that Engineering Education is at something of a crossroads, seemingly struggling to keep up with the rapidly changing nature of the Profession. Thus it is clear that if, as a Profession, Engineering is going to meet the expectations society is now placing on it, Engineering Education also needs to change. This paper argues that such change needs to be both pedagogically and Professionally driven, taking into account societal expectations and requirements whilst meeting Professional standards and quality.

Coining the term 'Engineering-Sociology' this paper contributes to Engineering Education and Engineering Education research practice and theory by proposing a new paradigm upon which future Engineering Education programmes and Engineering Education research might build. It argues that in order for Engineering to meet future challenges there needs to be a paradigm shift in Engineering Education and Engineering Education research. The Engineering-Sociology paradigm provides a framework upon which such a shift can be developed. Developed out of an approach to learning and teaching first proposed by one of the paper author's, Engineering-Sociology encapsulates both traditional and applied approaches to Engineering Education and Engineering Education research. It suggests that in order to meet future challenges there is a need to bring together what are generally perceived to be two diametrically opposed paradigms, namely Engineering and sociology. Building on contemporary theoretical and pedagogical arguments in Engineering Education research the paper concludes by arguing that by encouraging Engineering educators to 'think differently' Engineering-Sociology can provide an approach to learning and teaching that both enhances the student experiences and meets the changing needs of society.

Introduction: Engineering & Society

Over the past three or so decades, the role played by Engineering in promoting societal cohesion and change has shifted from Engineering being viewed as 'the backbone' of British Industry in the 1950's and 60's to it becoming a substantive and integral driving force that links society and science in an innovative and forward-thinking manner (RAEng, 2009). Indeed, it may be argued that Engineering advances over the past 10 years or so, have provided the impetus for much societal change. This is particularly the case when considering the area of digital Engineering and communication, but is also relevant when taking into account the wide range of other Engineering fields including power, medical, environmental and materials Engineering - all of which have seen innovative advances that have changed the way we live our lives. Yet despite such progress, in many respects Engineering remains a 'hidden' Profession. One which is generally low on the public agenda – only coming to the fore when disaster strikes.

By bringing Engineering and Society together it may be argued that in many respects, the Engineering Profession acts as Society's *glue* innovatively benefitting humanity whilst linking science and society. In the Developed World access to the Public Infrastructure (communication, transport, modern buildings, clean water, a ready supply of food etc) is taken for granted by an increasingly 'media savvy' population. Yet within this setting, very little thought is given to the Engineering innovation, and indeed the engineers behind what, in the UK and elsewhere, has become the 'expected' standard of life. Whilst science is generally given a 'high profile, Engineering is generally not on the public *radar*. Although as a discipline Engineering tends to view itself as distinctive from science, in many respects in the UK in particular, it has been subsumed into science and is viewed by many (non-engineers) as being a part of science.

The key question which therefore needs addressing by Engineering Educators and the Profession as a whole, is how to countermand this trend and promote Engineering as a viable, exciting and valid Profession – one that can provide young people with an intellectually stimulating and socially worthwhile career. It is this question that is at the crux of much Engineering Education research – much of which argues that Engineering Education needs to change if it is to successfully capture advances in Engineering.

Engineering Education Research: Time for Change!

The valuable role played by Engineering Education research in guiding and informing Engineering Education, both in the USA and also internationally is reflected in the literature (see for further discussion Borrego, 2007; Watson, 2009; Borrego & Bernhard, 2011) which, amongst other issues, discusses the role that Engineering Education research can play in increasing student numbers (Borrego & Bernhard, 2011) and the importance of applying research findings to practise (Watson, 2009). Other previous work has discussed the difficulties encountered by Engineering educators in undertaking pedagogic research. Wanket at al. (2002) identify conceptual difficulties experienced by engineers in learning and teaching research noting that problems with 'sampling' reflect the fact that students are far more complex to categorise than the more tangible variables engineers are used to working with in their discipline-specific research. Other aspects of pedagogic methodologies are also given attention in the Engineering Education research literature, with particular attention paid to problems experienced by engineers in identifying suitable approaches and tools with which to investigate learning and teaching approaches (Borrego et al. 2004; Borrego et al. 2009). Whilst questions relating to quality and rigour in Engineering Education research continue to drive attempts to improve quality in Engineering Education ultimately enhancing students educational experiences (Borrego, 2007; Borrego & Bernhard, 2011).

Previous literature has identified the value of collaboration across the disciplines being integral to improving the quality of global Engineering Education research (see for example Borrego & Newswander, 2008). Whilst the empirical and pedagogic value of collaboration cannot be disputed, pedagogically it is important that engineers remain the driving force behind Engineering Education research (Borrego & Bernhard 2011). Yet, whilst it is crucial that engineers take the lead in Engineering Education research, in order that the discipline is able to deal with the issues faced by contemporary society, it is also important that in doing so Engineering Education research practice is expanded to include a wide range of methodological concept and approaches (Borrego et al, 2009).

In many respects it would seem that Engineering Education and Engineering Education research is at a turning point. It is the right time for Engineering Education to be recognized and lauded internationally, not only for the quality of research being undertaken within the field of Engineering Education research, but also for the contribution being made to the wider pedagogic field in terms of both theory and practice. Yet, whilst there is much excellent work being conducted within the Engineering Education research community - Engineering Education research has not yet developed its own paradigm . It is this gap that the 'Engineering-Sociology' paradigm has been developed to fill.

Scholarship in Engineering Education

Previous work by one of the paper author's proposed a learning and teaching proposition developed to promote and enhance the student experience within Engineering Education. This proposition is:

Relationships + Variety + Synergy = Environment for Success (R + V + S = Success)

Developed to address the overall pedagogical aim of student success, the above proposition recognizes that one of the main challenges faced by Engineering educators today is how to create a learning environment in which such success can be nurtured and achieved. From this perspective there are three key components necessary to engender such an environment.

Crucial to the learning environment, Relationships [R] are key to successful learning – as such they need to be valued and nurtured (Cowan, 2006). Relationships in the learning environment reflect the complexities of the social networks encapsulated within and across educational settings. As such, different types of relationship exist between students and their peers, students and teachers, amongst colleagues and between those in education and other stakeholders including families, employers and other stakeholders such as policy makers. Previous studies have suggested that relationships play a vital part in addressing issues of retention by promoting a 'sense of belonging' (see for example, Read et al, 2003).

Variety [V] in learning and teaching reflects the need for Engineering educators to adopt an innovative approach. Whilst current trends tend to associate innovation with technology – it is evident that as a concept, Variety can incorporate so much more. Indeed, variety within the learning environment can include a range of different learning and teaching approaches including active learning, work-based learning, project and problem-based learning, to name but a few. Whilst it is imperative that all learning and teaching should be contextualized within a discipline-specific setting (Prosser & Trigwell, 1999) Engineering is in a fortunate position in that it can provide numerous opportunities for Engineering educators to introduce variety into the curriculum [laboratories: work-based learning: project-based learning: tutorials etc].

The third component, Synergy [S], captures the concept of constructive alignment (Biggs & Tang, 2006), but further develops this approach so as to encapsulate the requirements and expectations of a wider group of stakeholders including Professional bodies, industry and wider society. A synergenic approach to teaching involves deliberately designing the curriculum in such a way so as to engage students by providing realistic, relevant and interesting learning approaches that capture their imaginations whilst meeting university demands in terms of quality and content.

In introducing and then evaluating the RVS approach to learning and teaching (Clark, 2009), a new paradigm in Engineering Education has emerged. This paradigm (Kuhn, 1962) which encapsulates Engineering epistemologies and pedagogies within a sociological context has been termed 'Engineering-Sociology'.

Engineering-Sociology: A New Paradigm for Contemporary Engineering Education Research.

In the process of critically evaluating the pedagogic value of the RVS approach, it became apparent that there was a real need for a paradigm shift in Engineering Education and Engineering Education research. One of the most important considerations in n developing was the need to take account of *a priori* knowledge, practice and understanding in Engineering Education and Engineering Education research (Borrego et al., 2009). The SVR approach contextualises Engineering within its wider social setting; in doing so it brings together two seemingly diametrically opposed academic paradigms, Engineering and Sociology, into a single approach. Coining the term 'Engineering-Sociology' this paradigm firmly embeds Engineering Education and Engineering Education research into the wider social context. It reaffirms the role of Engineering as being a key driver of societal change and innovation, whilst providing the means by which Engineering educators can frame empirical research into Engineering learning and teaching practice and policy.

Given that sociology is likely to be an 'alien' field to the majority of this paper's readership, it is important to define what is meant by the term sociology. For the purposes of developing the Engineering-Sociology paradigm the American Sociology Association definition of sociology was used: *Sociology is the "study of society: a social science involving the study of the social lives of people, groups, and societies: the study of our behavior as social beings, covering everything from the analysis of short contacts between anonymous individuals on the street to the study of global social processes: the scientific study of social aggregations, the entities through which humans move throughout their lives': an overarching unification of all studies of humankind, including history, psychology, and economics''* (www.asenet.org). To put it simply, sociology represents the 'study of society'. In introducing a new paradigm, that of Engineering-Sociology, the importance of 'engineers', 'Engineering', 'Engineering Education' and 'Engineering Education research' to society is both acknowledged and promoted. Moreover, by accepting the integral role played by Engineering in advancing and supporting society, the paradigm logically leads to the suggestion that Engineering Education researchers should familiarise themselves with the wide range of sociological methods, paradigms and concepts available with which to empirically investigate and so enhance Engineering Education.

Engineering and Sociology are not natural 'allies'. Indeed, whilst previous (and perhaps current) generations of engineers may have argued that Sociology is not an empirically grounded field in the same way as Engineering or science, some social scientists are equally negative about Engineering suggesting that as a discipline, it cannot be defined as a 'true Profession' because engineers are not necessarily 'autonomous'[1] (Perucci & Gerstl, 1969; Ritti, 1971; Rae & Volti, 2001; Volti, 2008). It is therefore evident that, for the benefit of society in general, and Engineering Education in particular, much work needs to be done on both sides to breakdown long held and potentially damaging assumptions and stereotypes.

In developing the Engineering-Sociology paradigm, Engineering has deliberately been prioritised in front of Sociology. In doing so the paper authors acknowledge the fact that Engineering Education and Engineering Education research is essential about Engineering and as such must be led by those best placed to inform and shape the field (Engineering educators).

Concluding Remarks.

In developing and evaluating the RVS approach to learning and teaching in Engineering Education – and in proposing the Engineering-Sociology Paradigm built on this approach, the paper authors have taken account of the depth of previous literature analysing and theorising Engineering Education and Engineering Education research (see for example, Wiedenhoeft, 1999; Wanket et al, 2002; Borrego, 2007; Borrego et al, 2009). Although Engineering is deliberately given precedence over Sociology, the collaborative nature of the Paradigm should not be undervalued. Both Engineering and Sociology are vital components of the Paradigm, and each needs to be considered concurrently.

In conclusion it should be noted that the ideas expressed in this paper result from a Professional collaboration between an Engineer and a Social Scientist. Whilst this collaboration is on the whole very positive and mutually beneficial, it has not been without its difficulties and misunderstandings. Indeed, the fact that Engineering and Sociology are built on very different conceptual, epistemological, ontological and linguistic groundings makes such a collaboration a constant challenge. A challenge that is both academically enriching and Professionally demanding. Yet by encouraging Engineering educators to 'think differently' about Engineering Education and Engineering Education research, it is anticipated that the Engineering-Sociology paradigm will provide Engineering educators with the means by which Engineering Education can begin to meet the ever changing demands of 21st Century society.

[1] In a sociological context 'autonomous is defined as being able to make decisions without being directly influenced by a third party (such as managers).

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