Engineering Education Research - the UK perspective at a time of change

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ABSTRACT

Engineering education in the United Kingdom is at the point of embarking upon an interesting journey into uncharted waters. At no point in the past have there been so many drivers for change and so many opportunities for the development of engineering pedagogy.

This paper will look at how Engineering Education Research (EER) has developed within the UK and what differentiates it from the many small scale practitioner interventions, perhaps without a clear research question or with little evaluation, which are presented at numerous staff development sessions, workshops and conferences. From this position some examples of current projects will be described, outcomes of funding opportunities will be summarised and the benefits of collaboration with other disciplines illustrated.

Engineering higher education is well used to change. As technology develops the abilities expected by employers of graduates expand, yet our understanding of how to make informed decisions about learning and teaching strategies does not without a conscious effort to do so. With the numerous demands of academic life, we often fail to acknowledge our incomplete understanding of how our students learn within our discipline.

The journey facing engineering education in the UK is being driven by two classes of driver. Firstly there are those which we have been working to expand our understanding of, such as retention and employability, and secondly the new challenges such as substantial changes to funding systems allied with an increase in student expectations. Only through continued research can priorities be identified, addressed and a coherent and strong voice for informed change be heard within the wider engineering education community.

This new position makes it even more important that through EER we acquire the knowledge and understanding needed to make informed decisions regarding approaches to teaching, curriculum design and measures to promote effective student learning. This then raises the question 'how does EER function within a diverse academic community?' Within an existing community of academics interested in taking meaningful steps towards understanding the ongoing challenges of engineering education a Special Interest Group (SIG) has formed in the UK. The formation of this group has itself been part of the rapidly changing environment through its facilitation by the Higher Education Academy's Engineering Subject Centre, an entity which through the Academy's current restructuring will no longer exist as a discrete Centre dedicated to supporting engineering academics.

The aims of this group, the activities it is currently undertaking and how it expects to network and collaborate with the global EER community will be reported in this paper. This will include explanation of how the group has identified barriers to the progress of EER and how it is seeking, through a series of activities, to facilitate recognition and growth of EER both within the UK and with our valued international colleagues.

Keywords Engineering Education Research, UK Higher Education.

1. INTRODUCTION

As a consequence of the need to develop engineering talent capable of addressing the many challenges faced by our world, engineering education in many nations is coming of age. Often through an increase in visibility and by becoming 'self-organised', engineering education communities are becoming more firmly established. The situation in the UK has some additional components which are of particular interest and which may stimulate developments unlikely to occur in different circumstances.

The main change facing engineering higher education in the UK relates to a substantial change in the mechanism for the funding of teaching and the consequent impact this will have upon the relationship between university and student. These changes are coming at the end of a period of growth in student numbers in many of the main engineering disciplines and improved funding for higher education and have been brought about by spending cuts necessitated by the current global economic crisis. We will soon be entering a time when a more direct link will exist between the students' financial commitment and their learning experience. Graduates will be looking to critically judge the impact of their education as they enter the workplace with significant tuition fee debt.

In this paper members of the SIG will present their personal reflection upon the history and factors which have influenced the development of EER within the UK set against the particular institutional and funding changes currently facing HE in the UK. An autoethnographical methodological approach is used alongside narrative accounts to describe the personal experiences and reflections of the authors.

2. THE BEGINNINGS OF EER

EER has an important role to play in providing a solid foundation on which to build the engineering education for future students. It seems appropriate therefore to explore the role of EER in the UK and how, given the changes described earlier, future research will develop in order to provide the evidence base for future decisions and actions about engineering education in our universities.

The UK has a long tradition of higher education innovation within the engineering disciplines, sponsored by engineering institutions and informal staff groupings such as SEED (Sharing Experience in Engineering Design) of the late 1970s and 1980s. Of real value are also the notable cases of engineers who have contributed to wider educational development, An example would be John Cowan [1,2] who became a professor of education after an initial career as a structural engineer.

There have also been multidisciplinary pedagogic investigations which have included an engineering discipline, such as the ETL project [3] which identified distinctive forms of teaching within electronic engineering that required a pedagogy which connected the characteristic ways of thinking in the subject with the effective ways of teaching them. The project suggested caution when trying to relate findings in the discipline to generic principles and the value of collecting information from students about their experiences on specific units to obtain greater detail than is possible with broad evaluation forms.

In many cases, EER has manifested itself in small exploratory studies conducted by individuals in their own institutions. These studies have often been driven by the pragmatic demands of courses to explore new approaches to learning and teaching or through the research modules of Postgraduate Certificate programmes aimed at educating university staff about the practice and scholarship of learning and teaching. By their nature these short term action research projects are often not conducted with the rigour of what the EER community is trying to achieve today, but they are a very obvious and useful starting point for many academics.

A key point in the development of EER in the UK was the creation of a national mechanism of discipline based support for teaching innovation and also professional recognition of teaching qualifications for lecturers. In 1997 the Dearing Report, more specifically the "National Committee of Inquiry into Higher Education" [4] supported the raising of the status and professionalism of teachers in Higher Education (HE) through the formation of the Institute for Learning and Teaching in Higher Education (ILTHE), a body concerned with all aspects of teaching and its pedagogy.

The report recognised the direction that needed to be taken;

> *"We want to see the emphasis placed on learning rather than teaching, but the key to this lies in better and different approaches to teaching and guidance. Individual higher education teachers are not well-informed about the effectiveness of different approaches to learning and teaching."* [4]

And specifically for discipline focussed pedagogic research the report identified;

> *"We find it surprising that there has been little strategic research to monitor the consequences of recent changes in the students' learning environment and institutions' teaching activities. Although there is a substantial body of research about student learning, there has been little follow-up work into how some accepted principles might be translated into new teaching practices across disciplines and professional areas."* [4]

A further outcome of the Dearing Report was the formation of the Learning and Teaching Support Network (LTSN) in 2000 which consisted of a generic centre and 24 subject-based centres, importantly the Engineering Subject Centre (EngSC) based at Loughborough University. In 2004 a restructuring brought the LTSN, ILTHE and other bodies into one body, the Higher Education Academy (HEA) which included individual professional recognition of academics, as Associate, Fellow and Senior Fellow, as well as a network of 24 Subject Centres, including the EngSC (www.engsc.ac.uk).

The work of the EngSC has been instrumental in the identification of opportunities and support for enhancing the understanding of student learning within the engineering disciplines. In close collaboration with other organisations such as the Engineering Professors' Council (www.epc.ac.uk) and the Royal Academy of Engineering the EngSC has been able to make a direct impact through the direct funding of workshops, projects, awards, a journal and a bi-annual conference. Through financial support a maturity has developed within the projects supported which mirrors, and may in-part be responsible for, the coming of age of EER within the UK.

2.1 Classroom Innovations and Interventions

Within the UK the majority of academic roles within HE are designated 'research and teaching' yet in terms of recognition and promotion prospects, research performance is often prioritised above teaching [5]. Opportunities for improved scholarship are inferred but metrics are often difficult to define. This has led to teaching often seen as a short term interest and change being driven as a response to student dissatisfaction or arising from pressure from professional body accreditation.

Such an approach is the antipathies of EER in that it is driven by deficit rather than enquiry and a successful outcome is that the problem goes away rather than an addition has been made to the accumulated knowledge of engineering pedagogy.

This is not to reduce the value of classroom innovations and interventions, for many they have been the entry point to, and training for, EER. For the purposes of this paper we will consider a classroom innovation to be characterised by;

- being primarily driven by an issue or perceived problem,
- not fully reflecting on projects at other institutions or practices in other disciplines,
- not being fully evaluated, being measured against positive change (the students liked it or the marks went up) rather than what has been learned
- scale, usually one cohort, one department, one institution rather than being longitudinal, multi-cohort or multi-institutional.

There are numerous topics which have been the subject of a range of different classroom interventions, such as; active learning, computer assisted learning, assessment and feedback etc. which are reported in journals such as the International Journal of Mechanical Engineering Education [6] and the International Journal of Electrical Engineering Education [7]. The interface between interventions and EER is illustrated when such an approach is expanded in scale. An example of this is found in the PBLE – Project Based Learning in Engineering [8] study which was undertaken across four universities. The project also drew upon wider practice and produced a comprehensive guide which through the presentation of twelve case studies in a common format facilitates the reader in constructing an understanding of practice whilst also allowing the construction of further meaning using the comprehensive guidance section.

Many engineering academics have been supported in their classroom innovations by small development grant schemes run by their institutions but a national scheme run by the EngSC has through its structure and requirement for dissemination and evaluation also facilitated some projects at the boundary between innovation and EER [9].

2.2 Distinguishing EER

So what is it that distinguishes EER from classroom innovation? It may be suggested that within the UK context there are three distinguishing features; motivation, scale and structure.

Overall the aims of these activities are the same, a positive outcome for students, staff and other possible stakeholders. This is perhaps a rather short-term outcome in the case of a classroom innovation often being restricted to one teaching activity or module without consideration of the impact upon the overall learning process or accumulated ability of that cohort.

Currently a significant driver for classroom innovation within the UK may be considered to be the periodic accreditation visits made by the professional bodies, who are licensed by the Engineering Council to register Incorporated Engineer (IEng) and Chartered Engineer (CEng) professionals in accordance with the UK Standard for Professional Engineering Competence [10]. Accreditation visits often occur at five yearly intervals and are commonly a trigger for reconsideration of programme aims and currency, but whilst encouraging short term innovation this cycle does not fit well with the time scale of EER projects. This is an unfortunate circumstance as there are many similarities between the priorities for EER and the fundamental objectives of the engineering professional bodies, such as graduate abilities, engineer identity and motivation etc.

EER takes a more holistic view, seeking to understand the influence of the components of the learning process and their contribution to overall graduate ability within a specific field of engineering and subsequent professional practice through designed investigation, intervention and evaluation.

> *"No one would think of getting to the Moon or of wiping out a disease without research. Likewise one cannot expect reform efforts without research- based knowledge to guide them"* [11]

Figure 1 indicates that EER requires a structured approach to the problem. We know how to make simple changes in response to unacceptable circumstances, such as low attainment or student dissatisfaction but these are done to obtain short term change, i.e. approval by the next cohort rather than gain an increased and in-depth understanding of what is happening. Similarly we could hypothesise about student learning but not seek to test such notions, engaging in risk-free academic discourse. EER is distinguished by drawing both activities together, namely assurance of what is required and confidence in the steps towards achieving the planned outcome.

EER puts us in a position to understand actions which lead to student attainment and add to the pedagogic knowledge within the context of our own subject. This, by necessity, involves the identification of appropriate research questions, investigation of the literature, employment of appropriate methods for quantitative or qualitative data collection (or a mixture of the two), data analysis, interpretation and contextualisation and presentation of outcomes reflecting upon the original research question.

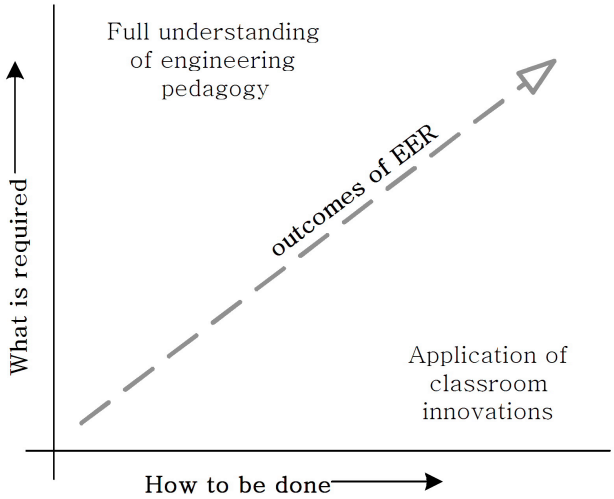

Figure 1

3. A TIME OF CHANGE

Higher education in the UK is embarking on a period of substantial change and uncertainty, most notably a complete overhaul of the funding structure. In essence the burden of funding teaching in HE will fall on the student, although deferred until graduation by a state funded loan. So what is the relationship between financial reform and EER?

The transfer of funding from the state to the student followed an independent review of higher education funding and student finance (the Browne Report) [12] which suggests that removing the predictable state teaching funding stream from universities will create competition and focus attention upon the quality of teaching.

> *"Many institutions claim to have improved the quality of teaching and to be focusing more on meeting the demands of students. However, the NUS [National Union*

of Students] and other student organisations have suggested there is no evidence that quality has increased as a result of the additional fee income." [12]

This new focus upon competition is being closely linked to teaching quality and graduate benefits, both to the individual and the nation as a whole. Within this new funding environment, engineering (with medicine and science) has been identified as;

"one of a number of priority courses that are important to the well being of our society and to our economy." [12]

This focus on the quality of teaching and also on the teaching qualifications of academic staff must be seen as a positive indicator that the profile of EER as a valid contribution to the discipline will become more widely recognised. But this does require those engaged in EER to be in a position to rise to the challenge and take advantage of where opportunity exists and seek to create further opportunity for the future. But will the Higher Education establishment support or permit this?

3.1 Current position of EER within the UK

The current position of EER within the UK has in many ways been derived from the professional focus of many programmes, having a strong leaning towards projects investigating the underlying aspects of preparation for the transition from study to the workplace, for example through student placements [13], or exploring the whole or parts of what may be classed as student centred learning, such as experiential and project based learning . These intend to engage students more fully in the learning process in order to obtain benefits beyond the acquisition of knowledge, in particular introducing learning activities that have the objective of giving the student an experience of what being an engineer is all about. UK EER is practically grounded with a clear focus on understanding the student learning process such that it results in both the recruitment [14] and retention of students in engineering. Such an attitude is also demonstrated in Australia [15] where there are many infrastructural and attitudinal similarities with UK engineering HE which is leading to some embryonic research collaborations.

As stated earlier, the work of the EngSC has been instrumental in the identification of opportunities and support for enhancing the understanding of student learning within the engineering disciplines. Specifically for EER help for academics entering the field of EER has been through the production of a Pedagogic Research Tool Kit [16] which introduces the main aspects of EER and, importantly for academics from a mainly quantitative discipline, discusses the need to approach the collection and analysis of qualitative data and generic educational literature with the same scholarly manner and values as are employed in engineering discipline based research.

The EngSC has also provided a focal point for academic networking and sharing, for example the establishment of the Engineering Education Research Special Interest Group, from which the authors of this paper are drawn, and guidance for the National HE STEM [17] programme which is funding a number of EER projects. These projects, informed by the HE STEM programme's focus on recruitment and retention in science, maths and engineering disciplines, are exploring topics such as threshold concepts, identity, approaches to learning and assessment of professional competencies.

As UK EER becomes more coherent in its activities and develops a confident voice (notably through the SIG website http://www.engsc.ac.uk/eersig) it is not only addressing internal engineering education research questions it is also seeking to engage with social scientists [18], to learn about their research approaches and methodologies as well as looking at the practices in other disciplines which may be different whilst seeking similar outcomes within their discipline context. Such a project, currently in its early stages, is starting with the hypothesis that "assessment of professional competencies in engineering could be enhanced by adopting similar approaches to assessment used in the medical professions". The project is being supported by the Royal Academy of Engineering within the National HE STEM Programme and is bringing together several of the members of the SIG.

There is currently a willingness within the UK EER community to draw their research questions from a broad range of areas: some of which traditional academics will see as absolute, some they may accept as contestable. It is part of the role of EER to demonstrate the nature of the changing world and the need of learning and teaching practice to take account of this. It is particularly pertinent at present as there is an inherent conservatism embedded in the UK system of accreditation and responding to employers. Employer representatives are generally seen as being in senior positions, possessing considerable accumulated knowledge but are potentially remote from the direct experiences of early career engineering graduates. This situation has contributed to a crowded curriculum and concern about the "expectations" of professional bodies [19] This is the type of accepted status quo that the EER community with its new found momentum can challenge and seek to explore.

For EER to develop its own position within engineering it also needs to become comfortable in its relationship with other disciplines. Engineering is a broad subject with ill-defined disciplinary boundaries. This prompts the question as to the position of engineering on a continuum between wholly vocational degrees (be they modern e.g. events management or traditional e.g. nursing) and non-vocational (eg philosophy or history). It may be suggested that as the World moves forward in the information age the vocational nature of engineering education, expressed through employability, will begin to redefine the balance of knowledge and skills we expect students to acquire when contrasted with the ability to self learn and reflect in an information rich changing World.

Recent work by Jesiek et al has demonstrated the growth and ever growing coherency of EER work across the globe [20]. The coming together of the UK community is an important step. The more established communities in the US, and to some extent Australasia, are now being joined, not only by the UK, but also communities in the Nordic countries [21], the wider Europe and South Africa. The Nordic example is perhaps most akin to the UK experience with a diverse group of interested academics seeking to learn about each other and find ways to collaborate around joint projects. As momentum builds, the impact of these individual communities and there contribution to the global whole will see EER firmly established as part of the engineering discipline and a credible area of research activity across most parts of the world.

In addition to EER becoming comfortable with its own relationship with other disciplines it also needs to be comfortable in the relationship between academics and students. Students are a fundamental stakeholder in the practice of engineering education and therefore must also be directly involved in the practice of engineering education research. This can take the form of students getting involved in EER as researchers themselves or through forming all, or part, of the research sample from which data is drawn. Being aware of students expectations, perceptions and experiences, adds an additional dimension to the EER activity [22]. It ensures that in addition to considering the academic view and

that of professional bodies, we can really understand the impact of the engineering education context on the students.

3.2 Looking forward

As UK engineering education moves forward within universities that are in competition with each other for the most able students there are some specific areas where EER may derive great benefit. In addition EER may also build a profile which challenges the view that learning and teaching is subservient to subject specific research in the mind of many senior academics. The Browne Report [10] calls for each university to publish, by discipline, the proportion of staff holding teaching qualifications as part of a suite of indicators designed to aid prospective students and their parents in making more informed judgement during the application process. Clearly for an engineering department to also publicly demonstrate engagement in EER, showing scholarship directly focussing upon application within learning and teaching, will be attractive to applicants and their parents.

EER by definition draws on teaching, scholarship and research, academic activities which do not always stand equally in terms of prestige. By providing engineering departments with an opportunity to bring together staff with differing, but in terms of EER often complimentary, skill sets for academic scholarship and the student experience will be enriched in a way that many desire but few see how to achieve.

EER has so far not been in a position to win significant funding, despite being relatively successful at obtaining small pots of funding from bigger government funded Learning and Teaching activities such as through the HE STEM programme supported by the Royal Academy of Engineering. This funding, however welcome, is not on the same scale as that exists for subject based research and is generally insufficient, in both financial value and duration, to employ dedicated workers in the area. The level of funding awarded to Centres for Excellence in Teaching and Learning (CETL) has enabled the funding of a number of PhD research studentships, for example as awarded to the engCETL (Loughborough University) contributed to EER projects including the funding of six full time EER PhD studentships (http://www.engcetl.ac.uk/research/studentships/). However the Higher Education Funding Council for England (HEFCE) has not been able to sustain this level of investment in the enhancement of Learning and Teaching. To grow EER needs to demonstrate opportunity to existing research funders that it is able to add value to graduates and therefore the economy. An excellent example of the need for EER is the call for more 'experience-led teaching' [23], an acknowledged resource intensive activity for a time of global recession where knowing what you are trying to achieve is one thing but knowing how to achieve it effectively is another. A condition illustrated by being constrained to the 'x' axis on Figure 1 presented earlier in this paper.

At present EER to a great extent falls between the different funding bodies remit. Perceived as neither wholly engineering nor wholly education, it is convenient for grant awarding bodies to pass applications from one to the other. This is not acceptable and should not be allowed to happen. The EER community has an important role to play in contributing to both engineering and education and, as such, should be recognised as worthwhile endeavour that requires support just as any other more established area of scholarship. A similar uncertainty rests with the upcoming assessment of research in the UK. Each institution is being left to decide whether it submits EER as part of its engineering submission or within an education area. EER is not properly recognised and consequently there has been no guidance on where it should best be placed. A growing community will establish recognition for EER and at some point these areas of uncertainty will become less so. The big question is when can we make this happen?

In addition to the work described above engineering as a discipline has previously been the subject of study by researchers from outside the discipline and any strengthening of EER will further highlight the opportunities presented by the discipline and its sub-disciplines. The variation of engineering sub-disciplines which are encompassed by EER serve to broaden its attractiveness to doctoral students from within the engineering field and from those with non-engineering backgrounds. The variety within engineering provides the opportunity for EER by PhD students to focus on the micro-level of a particular topic within one specific discipline, or from the macro-level research can focus on issues which may be common across a variety of engineering disciplines.

4. CONCLUSION

These are exciting times for EER in the UK and, in fact, across the globe. As the demand for high quality engineering education, academically challenging yet practically valuable, increases, a sound evidence based foundation that enables clear developmental decision making is critical. The growing communities in different parts of the world are now at a point whereby, despite the unfavourable funding regimes and recognition opportunities, they have sufficient determination and critical mass to make the statement that they are ‘here to stay’.

EER needs to continue to address fundamental research questions in a rigorous manner to ensure it retains a research profile, rather than receding back to a position of small scale practitioner classroom innovation. A fundamental aim of EER must be maintained as advancing our understanding of how students learn within our discipline.

The next step will be to address the view of EER in the minds of senior decision makers in institutions, funding bodies and industry to ensure EER gains the level of support necessary to ensure its future growth and the acknowledgement of its impact on the development of the engineering talent that is so important for the sustainable future of our world.

5. REFERENCES

1 [] Cowan, J. *On Becoming an Innovative University Teacher, reflections in action* 2nd ED. Open University Press. 2006.

2[] Learning to be a Professional: Using our own life experiences to develop principles for good educational experiences, 2009. http://learningtobeprofessional.pbworks.com/w/page/15914966/John-Cowan

3 [] Entwistle, N. Nisbet, J. Bromage, A. *Subject Overview Report Electronic Engineering.* Edinburgh University. 2005. http://www.etl.tla.ed.ac.uk//docs/EngineeringSR.pdf

4 [] The National Committee of Inquiry into Higher Education. 1997. http://www.leeds.ac.uk/educol/ncihe/

5 [] The Higher Education Academy. *Reward and recognition in Higher Education Institutional, policies and their implementation*. 2009. http://www.heacademy.ac.uk/assets/York/documents/ourwork/rewardandrecog/RewardandRecognition_2.pdf

6 [] International Journal of Mechanical Engineering Education (2011) http://www.manchesteruniversitypress.co.uk/journals/journa

l.asp?id=12

7 [] International Journal of Electrical Engineering Education (2011) http://www.manchesteruniversitypress.co.uk/journals/journal.asp?id=11

8[] Project Based Learning in Engineering (PBLE) *The PBLE guide: a guide to learning engineering through projects.* 2003. http://www.pble.ac.uk/guide.html

9 [] Arlett, C. Smith, A. Tolley, H. An evaluation of the impact of small-scale funding on the professional practices of engineering academics. *Engineering Education – Journal of the Higher Education Academy Engineering Subject Centre. 2, 1, (2007) 13-22* http://www.engsc.ac.uk/journal/index.php/ee/article/view/53/81

10[] Engineering Council. UK Standard for Professional Engineering Competence. 2010. http://www.engc.org.uk/professional-qualifications/standards/uk-spec

11[] Shavelson, RJ. Towne, L. Eds. *Scientific Research in Education.* National Academies Press. 2002. http://www.nap.edu/catalog/10236.html

12[] Securing a Sustainable Future For Higher Education, An independent review of funding of higher education funding & student finance. 2010. www.independent.gov.uk/browne-report

13 [] Lock, G. Bullock, K. Gould, V. Hejmadi, M. Exploring the industrial placement experience for mechanical engineering undergraduates. *Engineering Education – Journal of the Higher Education Academy Engineering Subject Centre. 4, 1, (2009) 42-51* http://www.engsc.ac.uk/journal/index.php/ee/article/view/121/162

14 [] Clark, R. Andrews, J. Researching primary engineering education: UK perspectives, an exploratory study. *European Journal of Engineering Education. 35, 5, (October 2010) 585-595*

15[] Lindsay, E. Munt, R. Rogers, H. Scott, D. Sullivan, K. Making Student Engineers. *Engineering Education – Journal of the Higher Education Academy Engineering Subject Centre. 3, 2, (2008) 28-36* http://www.engsc.ac.uk/journal/index.php/ee/article/view/108/140

16[] Morón-García, S. Willis, L. *Pedagogic Research Tool Kit*. Higher Education Academy Engineering Subject Centre. 2009. http://www.engsc.ac.uk/downloads/ped-r-toolkit.pdf

17[] The National HE STEM Programme. (2011) http://www.raeng.org.uk/education/hestem/default.htm

18[] Montgomery, C. Penlington, R. Tan, J. McDowell, L. Becoming and being an Engineer in an internationalised context: students' constructions of their experiences in Higher Education. *Proceedings of the Higher Education Academy Annual Conference,* (Harrogate UK, July 2008) http://www.heacademy.ac.uk/resources/detail/events/conference/Ann_conf_2008_Liz_McDowell?i=academyYork

19[] ALOE Working Group. *Assessment of Learning Outcomes in Engineering (ALOE) Final Report.* (September 2009) http://www.engsc.ac.uk/downloads/090904-ALOEWGfinalreport.pdf

20 [] Jesiek, BK., Borrego, M. and Beddoes, K. Advancing global capacity for engineering education research: relating research to practice, policy and industry. *European Journal of Engineering Education*, *35, 2, (May 2010) pp117-134*

21[] NNEER - Nordic Network in Engineering Education Research. 2010 http://www.didaktik.itn.liu.se/nneer.html.

22 [] McDowell, L. Penlington, R. Tudor, J. Initial findings of a mixed methods investigation into students' perceptions and approaches towards learning. *Practice and Evidence of Scholarship of Teaching and Learning in Higher Education. 5, 2, (2010) pp75-97* http://www.pestlhe.org.uk/index.php/pestlhe/issue/view/15

23 [] The Royal Academy of Engineering. *Engineering graduates for industry.* (February 2010) http://www.raeng.org.uk/news/publications/list/reports/Engineering_graduates_for_industry_report.pdf