Working Out and Working In Critical Interdisciplinarity

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Abstract: We are a team made up of an engineer and a social scientist, so we are constantly confronted by the challenges of working across the interdisciplinary gap. Engineers and social scientists share a vocabulary about research that makes it sound superficially as though we are talking about the same things, but in critical moments it often turns out that our values, methods and assumptions diverge markedly. It has taken many years for us to fully recognise and deal with the effects of these differences and, true to the nature of interdisciplinarity, every new project throws up new challenges and demands new adjustments. This paper summarises the fruits of those years and places them in the context of current thinking on how interdisciplinarity can be pursued in research and teaching.

Introduction

"most real world problems are complex and thus interdisciplinary" (Newell, 2000: 47)

The complexity of engineering products and services has increased remarkably in the past 30 years. A quick example is given by comparing the large range of engineering degrees offered today (ChemBio, Mechatronics, Nanomaterials, Aerospace, etc) with the simple range offered 30 years ago (Chemical, Civil, Mechanical etc). Much of the complexity has arisen from technological advances and also from the need to incorporate triple bottom line considerations where only cost and technical applicability was previously considered. Including environmental and social sustainability into engineering design has necessitated working in project teams made up of a wide range of specialists. It has become imperative for successful outcomes, that the engineer understands the language and methods of other disciplines. The views and knowledge of the biologist who advises about the rare animal that lives in the greenfield site, the requirements of the local community who abut the site, and the technical designer who will provided expertise on a particular component must all be incorporated.

We are all familiar with the ways in which this context of practice has meant a more sophisticated range of skills is needed in the practicing engineer, and hence in the curriculum. However, introducing teamwork and communication, while a good start, does not entirely prepare our students for a working situation which will require them to adjust their ideas about what counts as knowledge, what counts as argument, and what counts as progress, depending on who they are working with. It is such issues that we will consider here.

Epistemological constraints

Universities are generally organised in terms of either disciplines (e.g. sociology) or practices (e.g. education). The disciplines identify some kind of phenomenon in the world and make that the focus of their interest. The practices take a problem of a particular kind as their focus. Implicitly and explicitly in both cases, these starting points influence the understanding that can be reached as well as the behaviours of practitioners. Both disciplines and practices are supported by structural features such as appointment and promotion procedures and a hierarchy of publications which serve to reinforce the assumptions held by those disciplines/ practices and which militate against interdisciplinary practice

which does not conform to those assumptions. We trace some of the consequences and argue for interdisciplinary practice's power to achieve something neither disciplines nor practices can – the reformulation of knowledge.

Multi-, inter- or trans-disciplinary?

The simplest and most common way in which disciplines work together is simply additive "when the work of each of them is added to that of all the others" (McDonnell 2000: 27) and we understand this to be the multidisciplinary or cross-disciplinary approach. This leaves each of the contributing disciplines to work within their own worldview with their own standard methods, and this is an approach often seen in attempts to incorporate engineering and the social sciences within a single project. But someone is left to do the addition. If this happens during the compilation of a single summary report, those preparing it will inevitably do so from their own perspective or that of the commissioning body. If, on the other hand, the contribution of each discipline is supplied alongside that of the others with no attempt at synthesis, as in some edited collections, it is left to the individual reader to make what connections they will. In some settings, funding bodies take this approach when they commission a range of specialists from different disciplines with no or little co-ordination between them. Doubts have been raised over whether this is the best way to address complex problems such as those which arise in management of complex projects with social and environmental impacts (Klein et al., 2001). Instead a new approach which seeks new formulations of, and approaches to, such situations is widely advocated (McNeill 1999; Mansilla and Gardner 2003; Newell 2000). There is some argument over whether this should be called interdisciplinarity or transdisciplinarity and what the significance of any difference may be.

One understanding of these terms would have interdisciplinarity as an approach which starts with a complex problem, simplifies it by reduction to parts that can be dealt with by separate disciplines and then reassembles the resulting findings into an integrated answer (Lawrence & Despres, 2004). Newell (2000: 43) reminds us that "a perspective developed through interdisciplinarity is constructed for a limited use and may clash with another interdisciplinary perspective constructed from the insights of other disciplines to address a different question, issue or problem". In other words, there is no one interdisciplinary way of doing things or one interdisciplinary answer to any problem. At the other end of the spectrum, transdisciplinarity is often represented as a new way of understanding reality which acknowledges and works with its complexity by establishing new sets of axioms across sets of disciplines and yet is not to be seen as a new or super-discipline (Klein, 2004). While the impulse to avoid the time-consuming constant negotiation that interdisciplinarity involves is understandable, the tendency of transdisciplinarity towards the creation of new disciplines seems to us hard to resist. So while there may be much to be gained from conceiving of many complex problems in terms of transdisciplinarity, we prefer to maintain the flexibility and excitement that comes with the interdisciplinary task of responding to constantly changing circumstances with constantly changing approaches. In order to theorise interdisciplinary work so that its findings have wider significance than the solution of particular problems, Rowland (2003:17) advocates a 'critical interdisciplinarity' which "involves the learner in confronting the critique which emerges as different disciplines contest each other's theoretical frameworks, perspectives and practices". In other words, throughout the interdisciplinary process, a meta-level dialogue should be undertaken to identify, review and articulate mechanisms that are being used. We suggest that this kind of interdisciplinarity offers the most productive outcome when working across the very different disciplines we represent.

Crucial issues in research and intervention

We have found that working between disciplines requires a special approach. As per Young (2000: 221), we believe that this kind of work requires a problem focus as well as "expertise combined with an open and experimental approach; a common goal and recognition of the need for a common (or integrative) methodology; respect and trust among those working together; willingness to accept

leadership; leadership itself; clearly defined tasks and deadlines; and ethical accountability." In particular, our experience emphasises the need for:

- rethinking the more global aspects of research and intervention projects;
- allocating sufficient time to the project to allow for the contributions of various disciplines, especially where participant observation is to be employed. Time management can also become an issue where different disciplines, funding bodies and client groups have different notions of the proper tempo at which work should proceed (Coco, 2004);
- the privileging of particular approaches: care needs to be taken to avoid privileging one type of data or analysis and allowing for different participants' needs in terms of publications and career progression; and
- the building of common epistemologies. Commitment to regular and extended team meetings is necessary from all team members to keep such issues in everyone's sights and, most importantly, to build and maintain ways of conceptualising the problem that different discourses can understand (i.e. bridging epistemologies (Toussaint, 2005)). Even between disciplines that may be considered quite close such as anthropology and sociology, there is a need to find tropes from all participating disciplines' discourses which resonate with the partners and allow the development of a common language.

Bridging epistemologies

Toussaint (2005) describes her difficulties in getting natural scientists to overcome their dedication to the notion of absolute truth and appreciate the relativity of knowledge, in order to get local communities' points of view taken into account in water management schemes. She did this by using a standard text from physics which deals with the difference between observations made from different positions. The natural scientists felt at home with such an explanation and from there she was able to introduce wider meanings of relative knowledge. This is, of course, a familiar technique for specialists who need to introduce lay persons in the community to technical terms and understandings, using the knowledge people have to develop new understandings. Sometimes the development goes the other way and it is the specialists who need to adopt new ways of seeing a problem. For instance, during a project to address domestic violence in an indigenous community, one of us (Jolly) found she was having trouble making clear to the community just what phenomenon she was talking about. After many meetings and much discussion, finally one old man said "Oh, you mean that husband-wife business". In the context, his term not only defined the scope and setting of the issue but carried implications that, in local understanding, this was the business of husbands and wives and no-one else. Knowing that obviously changed subsequent attempts to address the issue. As a team, we have found that there are often moments in a project where we aren't getting through to each other and at those moments it has helped us to bypass words altogether and get our ideas into a diagram.

But is something lost in translation? For an anthropologist the concept of culture is key to understanding all human behaviour and one is inclined to feel hamstrung by its unimportance for technical professionals such as engineers. What complicates the matter is that the culture concept carries a host of implications for fine-grained analysis and intervention in an anthropological context; they don't need to be spelled out but these implications are not easily reduced to a simple definition or set of procedures that can be communicated to colleagues. While everyone might think we're talking about the same thing when we say culture, the lack of a real bridge between different understandings can lead to unfortunate results. In one instance, in a workplace dominated by engineers, research had been undertaken on how to improve online management systems. The main findings were that the culture of the firm was a major barrier and that aspects of management needed to change before any online system could work properly. No analysis was offered of what aspects of culture were problematic, how they worked, or what could be done about them. So although management acknowledged the need for cultural change, they put their energy into improving the technology itself. Such cases raise complicated questions about the power of single disciplines to define just what the problem is and what should be done about it. While the social sciences are by and large happy to work

with a high degree of ambiguity in the problems they deal with, engineers have been described as preoccupied with the solving of decontextualised well-defined problems preferably by mathematical means (Downey and Lucena 1997). The usual anthropological discussions of culture as encompassing everything and only loosely able to be used to explain human behaviour, does not fit well with a typical engineering approach and this has led us to explore ways of adapting the culture concept so as to render its parts measurable and able to be modelled (Jolly et al 2005).

Privileged Epistemologies

The pressure of pre-existing expectations can have an immediate effect on interdisciplinary work. As we mentioned above, in certain settings, the prestige of particularly valued epistemologies can render others almost silent, as when engineers' or scientists' positivist understandings of the world come into conflict with those of the social sciences. In one project, we had to go into mediation with members of the steering committee over the use of qualitative methods, so severe was their discomfort with a social science style of investigation and reporting. Numbers really are 'king' in many instances, and for good reason. They are commonly the only measure of progress and success that funding bodies pay real attention to. The consequence for interdisciplinary teams is that the 'soft', qualitative side of the work tends to be undervalued and in risk of being squeezed out, especially when time and funding become tight. This can only be combated by open negotiation amongst all stakeholders from the start of the project. We can provide an example of such negotiation from the writing of this paper.

Table 1 sets out an original piece of the text of this article as written by Jolly and the comment on it made by Kavanagh. There are clearly two ways of understanding what ambiguity means here. A typical social science constructivist view is that all understanding is partial and so little emphasis is put on things like close definitions. From this point of view, to speak of embedding ambiguity in data is a contradiction in terms. However to an engineer, ambiguity relates to things such as the over-specification of a problem, and this difference in understanding opens up space for a fruitful debate about the nature of ambiguity and its place in the curriculum (which is ongoing) and also for improving that part of the paper's argument.

Table 1: Text and comment

Original text	Comment
social sciences are by and large happy to work with a high degree of ambiguity, engineers tend to be focussed on well-defined solutions.	NO! Sorry ... this one stings ... we embed ambiguity and uncertainty in the undergraduate degree in terms of data and the fact that there is never one solution to a problem. I think ambiguity needs rephrasing .. do you mean undefined aims perhaps? I agree engineers will nail down what the problem is and what the aims/ KPIs are – that is fundamental to engineering. But so is the fact that often problems are ambiguous and over-specified and we then need to define where we will go.

The point here was not to decide whose understanding of ambiguity was right. Rather we were glad to find out that the difference in understanding existed, a fact that had not been obvious before and which we can explore productively in the future. It forced us to think more carefully about what we wanted to say and allowed us to be more precise in our argument. This is a relatively minor instance of epistemological negotiation but it is exactly out of such minor instances that a research collaboration is built. It is worth paying attention also to the emotional dimension of the interaction. We are all inclined to feel threatened when our assumptions are challenged and we need to be respectful of each other's feelings in our negotiations.

Time

All of the issues referred to above require significant time and mutual commitment for the team to work through. As Young (2000, quoted above) implies, the commitment must come first but in our experience the dedication of significant amounts of time to regular team meetings is the only way to achieve a common understanding of the goals (as expressed through constantly renegotiated bridging epistemologies), effective leadership and ethical accountability. Project teams that we have worked with, where various members of the team pursued their own interests with only occasional

management meetings, have not been successful and have been plagued with problems. Clients and community members became confused by the scatter-gun approach and team members ended the project with the feeling that they had not achieved as much as they might either in terms of the intervention or in terms of their professional interests. In another project, strict time constraints applied by the funding body encouraged us to have regular lengthy meetings, set explicit interim objectives and keep to our timeline for delivery. Although such constraints could cause problems in other instances, such as where the need to deliver interim results dictated the time available for careful qualitative work with communities, here we were able to use it to our advantage. Our ability to do so was dependant however, on our previous experience of working together and getting to know each other. We had already built at least the beginnings of a bridging epistemology we could work with, a set of common ethical standards, and mutual respect for everyone on the team.

Timing, or tempo, can also be a problem amongst the various stakeholders in any project. (Coco & Jolly, 2003; Coco 2004). The bureaucratic needs of powerful institutions can sidetrack projects, not least because of the different timetables involved. Where multiple funding bodies are involved, the situation can be complicated by different budget cycles and workers from various disciplines can be frustrated by the tempo of others' work patterns. For instance, some specialists expect to come to the community fully prepared and work at a smooth, even pace with regular communication of results. Others prefer to spend time with the community, only gradually gaining tempo in the production of results. These approaches can be equally frustrating within the one team and both can run foul of the community's natural desire to operate according to its own tempo. As always, respect, negotiation, long-term commitment, and the freedom to spend time together as collaborators is the only way over such difficulties.

Conclusion; implications for engineering education

In the light of ever increasingly complex projects and the professional expectations put on engineers to take responsibility not only for the technical aspects of their work but also for its social and environmental impact, some consideration of how to work in an interdisciplinary way seems both necessary and unavoidable. But in an already packed curriculum, how is it to be addressed?

Downey and Lucena (1997) describe a range of strategies for making engineering curricula and pedagogy more receptive to the sometimes different viewpoints of women and minorities. These authors see these groups as having an almost interdisciplinary position within engineering because their epistemologies, priorities, and assumptions about the context of engineering are likely to be different from those of the main stream. Their strategies for making fruitful use of these differences range from courses that examine the culture of engineering to the reframing of design problems to demonstrate that the boundaries around a given design problem can be drawn differently from different political and cultural perspectives. While adding more non-technical courses to the curriculum is always going to be problematic, any reframing of existing courses which encouraged consideration of alternative epistemologies and methodologies, including ways of managing time, would help develop the skills necessary for interdisciplinary work.

There is no way to tell in advance what the specific demands of any interdisciplinary project will be; each has to be negotiated in the light of current circumstances, the particular personnel in the team, and so on. So we cannot as educators provide our students with simple formulae such as "add 20% on meeting time". Instead we must teach them to value different approaches and have the skills to negotiate across disciplinary barriers.

While many of the research issues we have raised here will only be of interest to postgraduate students and researchers, they underpin the everyday work of contributing to a team on a complex project and hence demand our attention as basic aspects of engineering education.

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