

EDUCATING ENGINEERING ACADEMICS IN THE WORK PLACE THROUGH TEACHING COMMUNITIES

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Abstract *¾ The quality of education outcomes depends largely on the knowledge and skills of the staff creating learning situations. In Australian universities an expanding use of sessional staff to teach tutorials and laboratories, with a worrying diversity in interpretation of critical concepts, and teaching approaches, has threatened quality. At Swinburne University collaboration between engineering faculty and education experts has resulted in a process of workplace learning about teaching and student cognition that has transformed the education culture. Using problematic, large-intake undergraduate subjects as a context, Teaching Communities have brought together staff in a particularly powerful learning environment as part of normal subject teaching. Guided by the education experts, current student learning is debriefed, concepts to be taught negotiated, and appropriate teaching strategies decided. Academics have since developed an improved understanding of the complex, challenging domain of teaching, and their role within it. Measurable changes in teaching practice, student learning styles and outcomes, and curricula development have resulted.*

Index Terms *¾ Professional Development, Teaching Communities, Work-place Learning.*

A CHANGING WORKPLACE

While the profile of the student cohort studying engineering has changed dramatically in the last decade, the accepted practice of teaching engineering has remained fairly static in Australia. Some innovative programs have appeared in the smaller, regional university campuses, but the mainstream of engineering education is only slowly adapting to the needs of a more diverse group of students, and a changing workplace. A long and constant history of teaching practice in established universities has resulted in a degree of complacency and general acceptance of the status quo.

However, Australian engineering degrees have suffered from consistently poor student ratings in terms of quality of teaching [1]; some quite horrific failure rates in specific subject areas in many programs (such as electrical engineering); and recently have reeled from the Institution of Engineers Australia's criticism of graduates' team working and communication skills, amongst a range of concerns about engineering education [2].

To add to the pressure on academics many engineering programs, under financial duress, are creating 'super classes' containing large numbers of students drawn from many different degree pathways (and consequently very different knowledge bases and interests) in order to effect economies of scale, while simultaneously reducing contact time with students. Educational challenges are multiplying exponentially, while staff teaching in engineering have few opportunities, and little encouragement, to develop the skills to deal with them. Few academics have any formal training in teaching, or indeed much understanding of the complexity of the challenges they face as educators. As a result they are often, perhaps unfairly, condemned for their poor teaching, and are driven to the defence that they are employed as researchers not 'teachers', or that it is the students' responsibility to learn and they should not be 'spoon fed': either way attempting to absolve themselves of responsibility for bringing about change.

Academics in the 'new' universities created from the Technical Colleges (such as Swinburne University) or absorbed as new campuses of established universities, are often not active researchers. They are under great pressure from their university to develop their research output, and, due to their previous long experience as lecturers, already regard themselves as 'good teachers'. There is little incentive for them to invest time in keeping up to date with changes in educational knowledge, or developing their teaching skills to the higher levels required to cope with the new environment.

Paradoxically, while universities have been reducing contact hours – in particularly small group sessions such as tutorials – students have been clear in expressing the importance of such contact in establishing an understanding of the course content, and developing the generic learning, communication and team working skills demanded by industry. Both at a national level [3]-[5] and within Swinburne University [6] students explicitly acknowledge the vital contribution of good teaching in small groups.

Similarly, as the importance of learning communities [7] within student cohorts is being increasingly understood to be crucial not only to academic performance but university persistence and general satisfaction, the opportunities for

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students to develop strong communities are being reduced. Increasing numbers of students are provided less and less space to mix and work together, and are being encouraged to use on-line resources remotely as much as possible.

Swinburne University has a long history of teaching engineering, with many of the academic staff having been at the organisation before it transmutation into a university from a technical college some 20 years ago. Graduates are regarded as highly employable, with one of the best employment rates on graduation in Australia. In recent years, however, it has been recognised that problems were accruing, with the quality of student learning criticised by staff, and the quality of teaching criticised by students [6].

THE FIRST YEAR ENGINEERING PROJECT

The Swinburne University First Year Engineering Project (FYEP) was set up in early 1997, in response to a report by Arnott and Edwards [6], with the general aim of duplicating the success of a previous collaborative project at Monash University between the Education faculty and the departments of Software Development and Computer Science [8] [9]. The FYEP was established with a goal of creating an environment where students were encouraged to:

- learn in a deep rather than surface fashion [10] with an emphasis on conceptual understanding,
- form learning communities that encourage peer learning and university engagement,

and where staff, through a process of reflection on practice and in practice, [11] could:

- better understand the learning history, skills and needs of their students,
- develop teaching practices that promote student interaction and active engagement,
- adjust the curriculum content of their subjects to allow for more course objectives to be met,
- build a culture of constant development of teaching skills and awareness, as part of a community of teaching-oriented academics [6].

Clearly changes to the students' learning practices were going to be consequent on the changes to the teaching practices of the academics, so the first objective of the project was to engage the teaching staff in a process of professional development in their teaching role.

In the Swinburne FYEP one of the previously mentioned Monash education faculty members (Macdonald) was recruited as project leader to work with an existing Swinburne staff member currently completing a PhD through the Education faculty of Monash University (Arnott), and an experienced secondary school teacher/university academic (Edwards), to provide the education expertise. Crucially, all the 'education' members were either professional engineers (Arnott and Macdonald)

or had a science based doctorate (Edwards), providing a 'street credibility' in the target teaching area.

The initial set up phase of the project was quite complex, with many serendipitous coincidences that were advantageous [12] [13]. In particular the winning of a large government grant to support the project provided not only extra funds, but intellectual credibility. The latter was important, as Swinburne University has no education faculty. Most Swinburne academics were unaware that education research existed, while many saw education faculties as essentially teacher training institutes, rather than research organisation and a source of knowledge that may be relevant or useful to the practice of a university academic.

The first goal of the FYEP was the development of Teaching Communities [14] in all first year engineering subject teaching teams. Teaching Communities have previously been described:

"A mature Teaching Community... is the complete group of staff involved in teaching a particular subject, supporting each other to:

- Share experiences of teaching, both good and bad.
- Identify concerns about the students' learning styles.
- Identify concepts that are of particular difficulty and develop specific strategies to assist learning.
- Try new teaching procedures that may involve a degree of risk taking, or that require new skills.
- Use teaching and assessment practices that encourage students to communicate and form learning communities .
- Integrate lecture, tutorial and laboratory programs to provide flexibility and reinforcement of key ideas.
- Ensure that the content of a subject has internal coherence, and relevance to the practice of engineering.
- Identify and foster the acquisition of generic skills appropriate to the profession of engineering." [15]

Teaching Communities in the FYEP met either weekly for one hour, or fortnightly for two hours (the latter proving more effective as there was time for extended debate about concepts). It was the Teaching Communities that became the primary work-place learning environment.

The Teaching Community learning environment.

One of the essential philosophies of the Teaching Community approach is to avoid the 'deficit model'. Most university teaching support is provided on the basis that the teaching staff are deficit in certain skills, and require some sort of remediation through instruction. Workshops or seminars are then used to provide an input of general principles to 'fix the problem'. Inevitably the principles put forward are only approximately in context, and so are very difficult to translate into effective practice without intensive ongoing support. Academics, already offended by the implicit (or even explicit) criticism of their teaching

recognise that the suggestions are not directly addressing their own very specific challenges, and tend to dismiss them as 'impractical' and further evidence of the irrelevance of education support.

Teaching Communities are established with the clear and explicit intention of **improving student learning**. In the process it is expected that the curriculum, assessment and teaching approach will all be reconsidered. Any professional development in teaching ability is, for those involved, an incidental by-product. Without a carefully planned professional development process, however, the other improvements are unlikely to result.

Central to the development of a Teaching Community is an acceptance of the idea that good teachers are always seeking to improve their practice for the sake of their students and for professional pride. The best teachers are the ones in constant contact with their students; who are aware of what students are learning and not learning; and who are constantly seeking new ideas to support better quality learning. This is not a common conception of the teaching role, and not every academic cares about being a good teacher. In the Teaching Community meetings this is, however, a constantly recurring theme.

In the FYEP the 'education experts' had a dual role. As colleagues in the subject teaching group they were taking a normal teaching allotment, including small-group interactive sessions. They also brought to the group:

- knowledge of student learning processes,
- knowledge of the particular challenges being faced by students as they engaged in the transition to tertiary education,
- knowledge of framing educational principles that could help interpret the teaching and learning interaction in ways that could both highlight and celebrate good teaching practice (so that they could be shared and accessed by others) and also expose situations of poor learning in ways that allowed for specific counter measures to be taken.
- Knowledge of change processes, particularly in respect to teacher professional development.

In turn the engineering academics brought to the group:

- deep knowledge of the content area to be taught - in particular the important concepts and critical applications that professional engineers would require,
- knowledge of a wide range of teaching practices developed from experience, and in some cases from a sophisticated personal interest in pedagogy,
- knowledge of the likely areas of student misconception and learning difficulties,
- knowledge of the Swinburne University system, its resources and its limitations

A Teaching Community's primary focus is on students' learning, and ways to improve it. In order to communicate

ideas, and develop new techniques, a shared language had to be established. The jargon of education is as rich and meaningful as any professional jargon – and just as routinely misused in casual conversation. Partly to establish a common language, and partly to introduce some key principles about quality learning and small group teaching, a two-day workshop was run immediately preceding the start of each semester. Deliberately modelling many of the principles of good teaching, the workshop engaged staff in an analysis of small-group learning – with emphasis on the generally poor level of participation by students; the underlying reasons for this; and practical strategies to increase engagement. Full details of the workshop can be found in [16]. Experienced teachers found the workshop challenging, but often validating and fulfilling, while inexperienced (and often very anxious) sessional or post-graduate student teachers found it very valuable, with 'just in time' relevance. The ideas from the workshop became the framework for interpreting and predicting learning during the regular Teaching Community meetings. Some staff attended more than one workshop sequence by choice.

During 1998 three subjects were run as Teaching Communities, as staff were gradually recruited to the idea. By 1999 an Engineering Teaching Community had taken responsibility for the redesign of the entire first year program, negotiated a new first year curriculum, and established Subject Teaching Communities as policy for all first year subjects. [13]. During 1999 six of the eight first year subjects ran active Teaching Communities, with the two Mathematics subjects (provided as service subjects from another faculty area) the only exceptions.

OUTCOMES

During 1998 to 1999 the grant funds allowed an experienced education researcher (Walsh), and a research assistant, to work with the FYEP team to collect extensive data from staff and students. Further direct funding from the university in 2000 allowed the research to continue, but in a more limited form.

In individual interviews in 1998 and 1999 staff reported finding the Teaching Community meetings very positive in developing their understanding of the main concepts being taught in the subject, and in learning new teaching approaches that emphasised conceptual understanding and student-centred pedagogy. While some established staff found the collective responsibility difficult, the majority of staff valued the opportunity to engage in real debate with colleagues about teaching practice and theory [12][13].

Regular observations of small group teaching situations over 1999 showed that (averaged across all subjects for the year) 64% of tutorial time was spent in small group activities; two-way interactions between tutor and students or between students rose to an average in excess of 80% of tutorial time by second semester; while an average of 10 open and 16 closed questions were asked per hour of tutorial

time. Although baseline data was not collected in 1997, previous work in similar contexts at Monash University [8][9][17] suggest that these are very high incidences of such questions. Student interviews and focus groups that informed the original report into the state of engineering education at Swinburne indicated that student questions were rare, or were of 'surface' nature [6]. Staff who had taught first year engineering subjects at Swinburne through the development of the project, when interviewed, were also adamant that student interaction was far greater and of higher quality under the new teaching regime.

Observations of the tutorials also showed a marked increase during 1999 of good teaching practices such as asking open questions; increased wait time; withholding approval of answers until discussion was complete; and a decrease in the time spent in transmissive teaching, or answer-providing. While absolute values again had no baseline to compare with, the steady increase in these figures during the year indicated a development in the teaching skill of the staff being observed. Interestingly most of the staff were unaware of the changes in their teaching practice, with most saying in interviews at the end of 1999 that although they had found the meetings interesting and worthwhile they did not feel they had changed their teaching significantly. Change in practice appears to be due to change in fundamental understanding, and through 'osmosis' of teaching methods from the descriptions of other staff in meetings, rather than by conscious decision making.

Instrumental in these changes to teaching practice were changes to the tasks set for tutorials: a greater emphasis on group work, student-generated ideas, project work, and assessment items that had to be completed in teams.

Focus groups of first year engineering students clearly identified the emphasis on small group teaching techniques as being instrumental in developing supportive learning groups (learning communities) that were of great assistance in coping with academic demands and easing the transition to university. By year's end 58% of students regularly participated in a learning community, and found them valuable. Students also acknowledged the emphasis placed on conceptual understanding in the design of the curriculum content. Not only did they see this as sound educational theory, but were prepared to adapt their learning style to suit.

The Swinburne University Quality Unit student surveys also showed that 64% of students felt that the teaching encouraged them to work with other students, while 68% were satisfied with the overall quality of teaching. Academic results were solid, despite a shift to more conceptual questions in examinations, a change regularly resulting in a significant drop in performance in other contexts. Most subjects had a more diverse range of assessment items, so again final academic results could not be meaningfully compared with previous years.

By the end of 1999 the data clearly showed that there had been a considerable shift in the learning approach of the first year students, compared to previous years. This was

achieved by deliberate changes to the content being taught, the tasks set as learning contexts, the teaching practices in lectures and tutorials, and in the assessment structures. All these changes were brought about through collaborative decision making in the year level Engineering Teaching Community, and in the individual Subject Teaching Communities [13].

Many of these changes had been mooted in the past by individuals, but had been deferred, defeated or derided out of consideration by those who preferred the status quo. Such wide ranging and comprehensive change in such a short time scale was not due to autocratic 'top down' implementation of policy, but a result of a development in the beliefs (i.e. education) of a large number of the staff who owned the first year program – while they were actively engaged in their workplace: that of teaching a first year engineering program.

WHY TEACHING COMMUNITIES WORK.

Teaching is an activity which involves strong emotional engagement. It is intensely personal, demanding and yet potentially very rewarding. Teaching is a profession with a high moral purpose [18][19] and few who engage in teaching take it lightly. Practitioners usually have a strong belief structure which guides what they do, and so changing teaching practice is not simply a matter of receiving information about a 'better' way to teach and applying it faithfully – it involves changing a complex set of conceptions and attitudes that guide the decision making of the teacher. Change, then, is extremely difficult to bring about, requiring learning of a very 'deep' kind if there is going to be anything more than token alterations to practice through the 'picking up of a few tips' – the often expressed outcome of conventional teacher training.

Experience in working with teachers at Secondary and Tertiary level (often in environments hostile to change), and a deep immersion in the rich range of literature about learning theory, professional development and change processes (too diverse to attempt to cite in full here), has led the team involved in the FYEP to develop some guiding principles for successful learning. We have concluded that successful 'deep' learning environments:

- Are not be seen by the learner as 'fixing' a knowledge deficit in the learner, but are seen as an opportunity to continue to develop and improve on current knowledge.
- Are long term and incremental, not a hurdle to be jumped to achieve a qualification.
- Are on a need-to-know basis, where new knowledge has immediate utility.
- Foster learning primarily by social interaction with peers – with knowledge construction guided and validated by a trusted expert.
- Are as closely situated in the required context for use of the knowledge as possible, to limit the need to translate theory into practice.

- Engage the learner in active construction of meaning to solve a real problem in a social context.
- Encourage risk taking and experimentation, with assessment that does not focus on mistakes, but rewards learning.
- Give ample opportunity for reflection on practice, and in practice [11].
- Give immediate constructive feedback to any attempts to change.
- Provide a constant sense of progress and self-efficacy.

Teaching Communities, when run well, are remarkably consistent with this set of requirements. The highly situated, and strongly social nature of the Teaching Community complements the intensely emotional experience of teaching; continuous reflection on student reactions and feedback from fellow teachers provides immediacy and a sense of development; while the next round of classes provides many powerful ‘need to know’ contexts with very real problems to be solved in the social structure of the classroom dynamic. Meetings can, at times, become intense and highly philosophical debates about fundamental issues of learning, even when quite simple concepts are about to be taught.

Opportunities for any teachers to meet and discuss teaching practice, and their own understanding of the concepts they teach, are rare at best. The remarkable success of the Project to Enhance Effective Learning (PEEL) [20][21] in secondary education can be at least partially attributed to the regular meetings of the participating teachers in which high levels of trust were built up, allowing members to freely reflect on their teaching, share what is often implicit knowledge, and hence be more creative and take risks with new teaching techniques.

Structurally, it has become apparent that the ‘education experts’ play a crucial role in the functioning of the Teaching Communities. Without the presence of someone with the authority of having accredited knowledge in the field (a very powerful factor in academia) educational debates cannot be framed in coherent ways and lessons learned. Arguments without interpretation and resolution often lead to frustration. While not wanting to be in any way ‘taught’, the members of the Teaching Community want guidance in understanding what has happened and advice in planning suitable response. Diplomacy, tact and the capacity to redirect discussions back onto the ‘education high ground’ are key requirements for the education experts, as is regular attendance at meetings. Left to their own devices meetings often degenerate into arguments about abstract concepts, and student blaming.

Another lesson learned from the FYEP concerned consistency. When only three subjects were involved in Teaching Communities, during 1998, students did not get a consistent message about what was valued in the engineering program. Even though the individual subjects were rated highly by students in the Quality Unit surveys,

students were not engaging in learning communities as a general strategy. In 1999 and 2000, when six of the eight first year subjects were consistently putting forward the message that conceptual understanding was important, and that fellow students were a valuable source of learning and emotional support, students responded by forming learning communities; asking questions to ensure understanding beyond the superficial; and taking a more active responsibility for their learning outcomes.

Poor learning approaches by students have to be interpreted as an intelligent coping response to the context in which they find themselves, rather than a character fault of the students. When students understand the value of a ‘deeper’ learning approach [10], and see it rewarded, they are more inclined to choose to use it.

By the end of 2000 Teaching Communities had become standard practice in the first year engineering program. Academics teaching into these subjects expected to meet regularly and discuss their students' learning, and negotiate the best way to introduce key concepts. Meetings were a normal component of the job, rather than some form of special imposition. Reflection on practice had become a part of the job, and hence professional development in teaching practice became part of the culture of the first year engineering community.

Perhaps the most important aspect of the success of the FYEP has been the sense of community that has developed amongst the first year group. The regular collaboration through the Teaching Communities has nurtured a culture that embraces dynamic complexity, and sees a conflict of views as a chance to learn rather than a sign of discord and disunity. While the processes within such collaborative cultures defy detailed analysis, their success is well recognised in both education and business [18][19].

ACTION RESEARCH ON TEACHING.

The ambition of the FYEP team is now to engage more of the non-education qualified staff in research on their teaching, in collaboration with the ‘education experts’. In this way time and effort expended in improving teaching will not only result in improved student learning and a clearer understanding of the specific issues facing the program at Swinburne University, but will also generate highly valued research publications, and continue to build the credibility and standing of those engaged in teaching development. A previous project at the then Faculty of Computing and Information Technology of Monash University had exactly this outcome: prior to the project teaching was not seen as a research area, and staff committed to improvements in teaching were in danger of losing their jobs for not focussing on their ‘mainstream’ research. After three years of change a new research group was formed to work on computing education research (the Computer Education Research Group CERG), and one of the original team went from precarious employment to full

professor status after winning the Commonwealth Government's 'Lecturer of the Year' award. Teaching Communities continue to operate and proliferate in the faculty, and have become a focus of further research publications.

One of the greatest threats to the continued success of such projects is higher management indifference to the importance of researching teaching practice **in context**. Old fashioned views that research on teaching and learning is the strict purvey of Education faculties and not relevant to engineering academics threaten the long term future of engineering programs that are struggling to keep up with student and industry expectations.

Modern companies accept the vital importance of being learning organisations that can respond quickly to new challenges, and constantly develop new and innovative products, through constant development of their own staff [18]. Work-place learning is a mantra in powerhouse companies. Universities have exponentially increasing challenges that require equally determined responses that not only draw on the current teaching skills of their staff, but actively develop them [22]. Research is central to academic life – the challenge now is to incorporate action research on teaching through reflective practice into the agenda of all teaching academics. Teaching Communities are one way to do so.

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