

**Supporting Staff and Students in Improving Practical Experiences in an Engineering
Department – Submission ID 0071**

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Abstract

In 2006 the Department of Engineering initiated a research and development project to investigate and improve the practical experiences (coursework) through which students traditionally explore diverse engineering disciplines and begin to develop their professional expertise. This work was undertaken with the support of, and in collaboration with, the Teaching for Learning Network at the University of Cambridge, building on central commitments and methodologies emerging from the network's engagement in other disciplinary contexts. This paper aims to examine *how* these commitments have transferred from their original context within the Plant Sciences Department and manifested themselves in a different discipline to support different goals, and *what* it is that transfers.

The Department of Engineering has a commitment to providing its students with exposure to a wide range of engineering disciplines (such as Chemical, Mechanical and Aeronautical Engineering) in their first and second years in order to build a solid understanding of common engineering concepts before students specialise in the final two years of their degree. Teaching in the department is primarily carried out through lectures that lay down the overall conceptual structure of each discipline, which is then reinforced during practical sessions (coursework). Coursework is also regarded as providing vital training in core professional practices. However, over many years the two elements of the course have become detached from each other and coursework no longer provides a practical reflection of taught concepts.

In order to effectively illuminate current coursework practice in Engineering and establish the space into which evidence-informed improvements would fit, a multi-method research agenda was designed, drawing on the expertise of educational researchers to initiate and co-ordinate research activities, but emphasising engagement by practitioners embedded within the Engineering discipline to translate methodologies into their specific disciplinary context. This commitment to practitioner engagement is the first of the themes that has moved from one context to another. The second transferable theme is a commitment to gathering mutually supporting datasets, which when analysed provide compelling evidence within their originating context.

This participatory approach had far-reaching results. The consensus was that improvement to the coursework experience was not a simple matter of curricular design, but would also require training and support of teaching staff ('demonstrators'), a need to capture and build on the tacit teaching skills and practices of experienced staff and the provision of additional resources to staff and students allowing further exploration of troublesome conceptual areas.

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Introduction

This paper discusses innovations in curriculum development in the Department of Engineering at the University of Cambridge, undertaken as a participant in the Teaching for Learning Network (TFLN), and the role of the network as a neutral space facilitating a research project with rapid development outcomes.

The Engineering Department has a long commitment to providing all its first and second year students with exposure to a wide range of engineering disciplines, including mechanical, electrical, information and civil engineering, and to developing skills in engineering design and management. The course structure allows students to develop a sound understanding of the fundamentals of engineering science before specialisation in the final two years of their undergraduate degree. Teaching in the department is primarily carried out through lectures that lay down the overall conceptual structure of each discipline; this is then reinforced and further explored during practical sessions (coursework). Small-group teaching in the Department is customarily based on use of 'problem sets' which act as paradigms of engineering principles, the solving of which is intended to point towards the development of an integrated understanding of the subject and ultimately demonstrate development of professional expertise (See Figure 1 for an overview of the structure of the undergraduate degree).

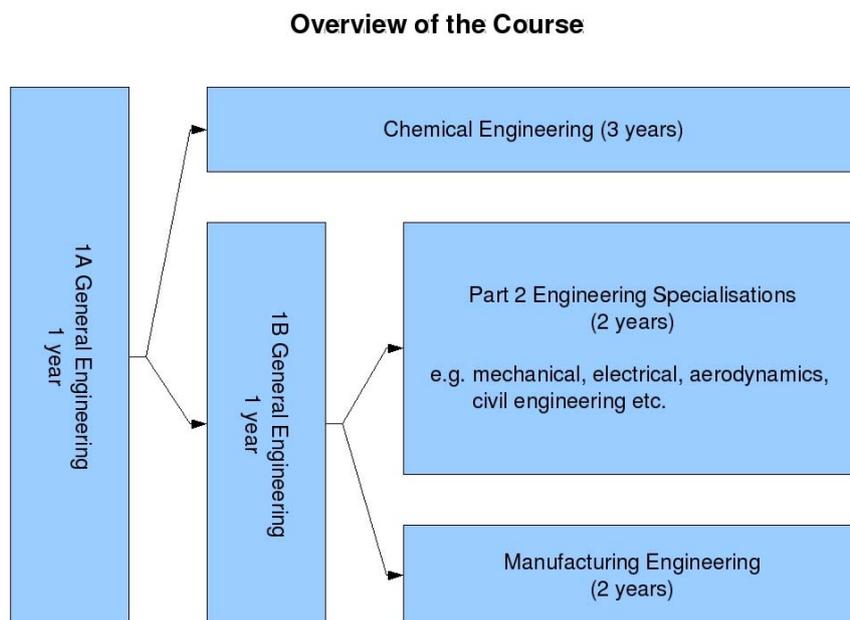


Figure 1: An overview of the structure of the undergraduate engineering degree, showing the common foundation in years 1 and 2 and specialisation in years 3 and 4.

In 2006 the Engineering Department initiated a research and development project in collaboration with the TFLN at the Centre for Applied Research in Educational Technologies (CARET). The project was designed to investigate and improve the coursework sessions for second-year



undergraduates, through which they traditionally explore the diverse engineering disciplines, apply and extend the knowledge gained in lectures and other settings, and begin to develop their professional expertise. The initial driver for this project was the staff perception of a significant lack of student engagement with and enthusiasm for the existing short coursework sessions. In addition there was a growing sense of 'conceptual fragmentation' across the teaching context and a corresponding lack of integrated understanding of engineering fundamentals at the end of the second year, negatively impacting on further specialised study by students in their third and fourth years. Engineering problems are complex, requiring a professional engineer to bring analytical skills and integrated conceptual understanding together in finding a solution; over many years, the conceptual content of lectures, problem sets and coursework had become 'detached' from one another, and so gaining such an integrated understanding was proving increasingly difficult for students.

Engagement with the Teaching for Learning Network

The project began in October 2006 with the recruitment of a graduate of the Department of Engineering to act as a domain-specialist embedded within both the Department and the TfLN. An education researcher based at the Centre for Applied Research in Educational Technologies (CARET) at the University worked in collaboration with the domain-specialist. This collaborative relationship, with two researchers occupying a 'liminal state' (Turner, 1982) within each other's discipline, conferred the status of 'allowed outsiders' or legitimate peripheral participants (Lave and Wenger, 1991) on both researchers and gave them the freedom to raise questions, engage with staff and students for the purposes of research, gain a neutral overview of the current situation within the Engineering Department and ultimately to act jointly as brokers between the TfLN and Engineering (Garsten, 1999; Burt, 2005). This pattern of engagement is reflected in the other accounts given at this roundtable (Irvine and Carmichael, 2007; Tracy, Jordan and Johnstone 2007; Hill, 2007).

As Engineering joined the TfLN, the network was undergoing transition with individual research 'tools' becoming instead a cohesive body of research methods and meta-analytical themes suitable for decontextualisation and subsequent deployment in different disciplinary contexts. Additionally, there was an accumulation of distributed expertise within the network as individuals explored their own disciplinary contexts using a variety of methods and a process of ongoing co-interpretation of the results took place within the network. This allowed early research in the Engineering context to be turned around into early development work on the new coursework sessions: this was of vital importance in order to prepare new coursework infrastructure on time for the next cohort of second year undergraduates who would have their coursework sessions in October of the 2007-2008 academic year.

Attendance at weekly meetings of the TfLN facilitated the process of reflection on and the reframing of the research question into a multi-method research agenda that could be undertaken



collaboratively by the embedded researcher and the educational researcher. The TfLN acted in this as a 'neutral space' where all enquiry was legitimised and co-construction and co-interpretation activities within the group supported practitioner reflection and engagement (Carmichael and Irvine, 2007). These activities allowed the development in the Engineering context of an agenda in which research and development activities in teaching and learning were closely interlinked. A commitment was made to engage staff and students within the department as participants in the research process.

Providing support for conceptual integration across the student learning environment was an over-arching theme for future development in the department. The engagement with the TfLN as an external network already facilitating successful evidence-based interventions in other disciplinary contexts was seen as a commitment to warranted development.

Shaping the research agenda

The next cohort of students was due to take these coursework sessions in the 2007-2008 academic year. A research agenda through which data could be gathered, analysed and interpreted was proposed and initiated in order to allow the parallel development agenda to begin as soon as possible. The research project, designed not just to investigate but to inform changes to practice, began initially with a simple transfer of previously warranted research methods from one context to another; a 'practice-value' questionnaire previously used to great effect in the Plant Sciences Department (Carmichael *et al* 2006) was administered to second year students to highlight areas of concern with current coursework practices.

During this first phase of the research project, the results of the p-v questionnaire informed early development of the new coursework sessions, directed at improving the integration of the coursework sessions with other teaching environments for undergraduates and clarifying the connection of practical and theoretical conceptual frameworks. Furthermore, as the results of this questionnaire were co-interpreted within the TfLN, further areas for investigation were suggested, and via a process of brokerage through the wider TfLN network, a second phase of pedagogic research to further explore aspects of the staff perceptions, student perceptions and the learning context was planned.

There was a commitment undertaken to the deployment of multiple research methods illuminating and substantiating results of previous research; such triangulation data was vital both for transparency and to inform engagement with staff within the Department and to provide a substantiated evidence base for development and informing further research. This evidence-base built on central commitments and methodologies emerging from the TfLN's engagement in other disciplinary contexts (as described in Irvine and Carmichael, 2007).



Intra-departmental brokerage activity between the Engineering department and the TfLN through the agency of the embedded researcher and an educational researcher communicated research findings both back to the department and to the TfLN and assisted the translation of those findings into both further research and ongoing development of new coursework sessions.

The second phase of research to illuminate further the initial findings included classroom observations, semi-structured interviews with demonstration staff and student focus groups. Informal discussions with staff and students was also undertaken by the embedded researcher, to feed back emerging analysis from this research to the developers of new coursework within the Engineering Department; to further engage staff with this process; and to ensure alignment of development and pedagogic theory and research findings.

From the start of this project, there was also a commitment made to the engagement of staff and students as participatory co-researchers within the department in order to document their perspectives on current practice and potential areas for development of that practice, as well as to effectively engage them in a process in which research and development activities ran in parallel. In this way, an overview would be assembled of the context that was as comprehensive as possible and that also called out and involved a full range of voices from staff, students and collaborators within TfLN, and ensured that staff and students felt a sense of 'ownership' of the developments. This intra-departmental brokerage and engagement also generated an interest amongst staff in an agenda for further research and development.

Results of the research

Initial results from the p-v questionnaire indicated that students felt that coursework sessions were too prescriptive; there was too great a reliance on 'the handout' as a ritualised teaching artefact; coursework did not relate to or assist in understanding the overall conceptual structure of the course, and was not related to 'real life' or authentic examples of engineering expertise. These findings were reinforced during focus groups with students, where they additionally identified a lack of understanding of the overall conceptual structure of the undergraduate course by demonstrators as an issue negatively impacting on their engagement with the sessions.

Classroom observations of coursework sessions highlighted strongly contingent teaching by staff, who acted quickly to correct any deviations by students from the rubric laid out in the coursework handout, but rarely engaged students in discussion around their errors or how the concepts being explored related to the overall course. In interviews with staff teaching during coursework sessions ('demonstrators'), it was discovered that they received no formal training or support for their vital teaching role in coursework sessions, and had instead developed 'survival strategies'. These were usually based on 'received wisdom' and relied on the preparation of scripted answers to issues raised anecdotally by students during sessions. Demonstrators are generally not teaching staff, nor a member of that community within the Department; instead they are most



often postgraduate research staff, and their uncertainty about their teaching role and the corresponding reliance on 'the handout' as the central authoritative artefact provided an insight from the staff perspective of the issues raised by students in their p-v questionnaire and elaborated on in focus groups.

Brokerage, engagement and developing roles

The research and development work on new coursework sessions was made possible by the close collaboration of the Engineering department with the TfLN. In the early phases of the research, membership of the TfLN allowed first discussion and then framing of the research question and assisted in determining the potential ways in which to gather the necessary data to begin answering that question; in this way, an adapted p-v questionnaire could easily be administered to Engineering students within a very short timescale. Similarly, when data arising from this questionnaire was co-interpreted by the group, further avenues of investigation were made readily apparent and could be quickly pursued, allowing the development process for creating and structuring new coursework to proceed.

The process of engagement also allowed the embedded researcher in Engineering and the educational co-researcher to begin defining their roles in relation to each other, the research programme and the TfLN as a community of practice. These roles were flexible enough to allow brokerage first of research methods into the engineering context, but as the co-researchers underwent their own process of reflection and development, their roles as brokers between the communities in Engineering, the educational researchers at CARET and their co-researchers within the TfLN became increasingly clear to them and their 'translation, coordination, and alignment between perspectives' progressively sophisticated (Garsten, 1999).

Membership of the TfLN extended beyond the transfer of research methodologies from a warranted context into a disciplinary research agenda. The adoption of the central analytical frameworks described in earlier contributions to this roundtable (Irvine and Carmichael 2007; Tracy, Jordan and Johnstone, 2007) and commitments to engaging staff and students as co-researchers ensured that full consultation with staff and students was taken and new coursework sessions were developed on a sound evidential basis to satisfy the requirements of everyone involved.

The engagement of staff and students within the Engineering department was an intra-departmental translation of the theme of brokerage, a key commitment arising from work within the TfLN and described in detail in Irvine and Carmichael, 2007. Discussions with staff in the Department combined both research findings and feedback on that research and also allowed iterative refocusing of coursework session development.



This brokerage of research and pedagogic theory back to staff and the creation of new coursework and an emerging community of demonstration staff aligned the project and its outcomes with Burt's description of 'level 4' brokerage, whereby co-configuration across several communities of practice allowed the synthesis of new behaviours and beliefs within the Department of Engineering (Burt, 2005).

Outcomes of the research and future development

The inclusive research agenda had far-reaching results. The consensus was that improvement to the undergraduate experience of coursework was not a simple matter of creating new coursework sessions, but involved wider issues of curriculum design, and would also require training and support of demonstration staff, a need to capture and build on the tacit teaching skills of experienced demonstration staff and the provision of additional resources to staff and students, allowing further exploration of troublesome conceptual areas.

Analysis of the data generated by the research outlined above identified three potentially 'high-leverage' strategies for improvement in undergraduate teaching:

- The development of a more integrated teaching framework, within which coursework sessions could be contextualised in relation to other learning situations;
- A more transparent and integrated conceptual framework across the undergraduate course, where theory and practice were more closely linked;
- The development of practical work more reflective of the complex problems facing professional engineers.

The evidence collected informed the development of a suite of integrated coursework sessions arranged around the central concept of 'Buildings in an earthquake' and involving four of the seven 'teaching schools' within the Department. These new 'integrated coursework sessions' were carefully linked to other course elements and reinforced central concepts in engineering.

There is also a programme currently in hand to restructure the course offered to first and second year students, providing 'throughlines' by clarifying the conceptual link between lectures and coursework; linking first year coursework to second year coursework by explicitly revisiting concepts previously taught; and by integration of concepts explored in coursework into examples sets (Biggs, 1999). See Figure 2 for an overview of the throughlines established in undergraduate engineering, and the place of the newly developed coursework sessions (labelled as 'New Labs') in supporting this integration.



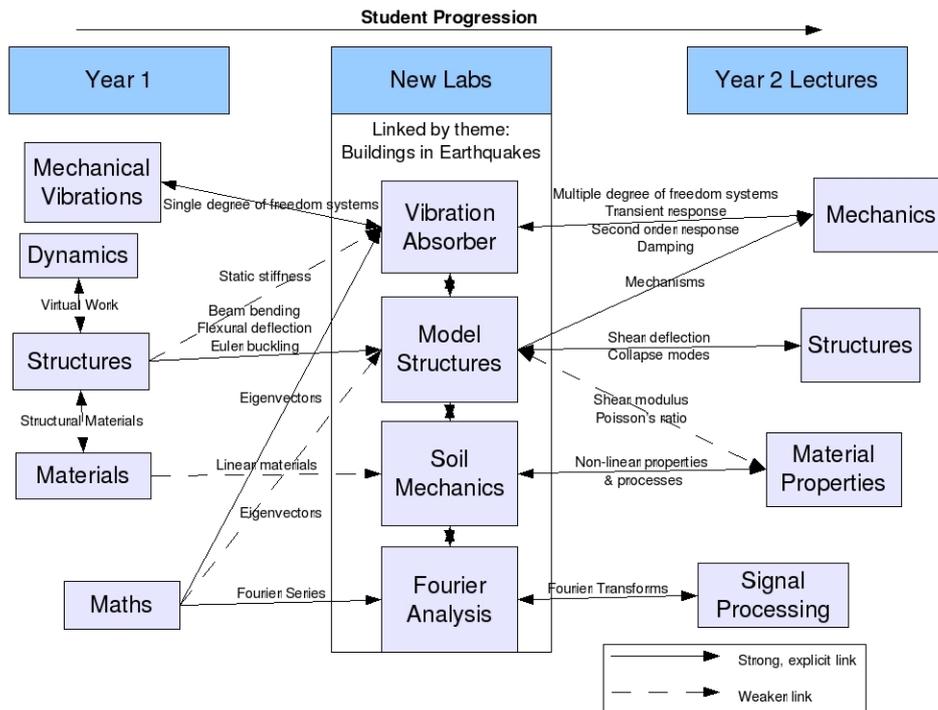


Fig. 2: An overview of the integrative function of the newly developed coursework sessions within the conceptual structure of the undergraduate teaching curriculum.

Demonstration staff training and support will be offered by a series of workshops to be run later in this academic year, exploring simple teaching methods and discussing the role demonstrators have to play in student learning. These workshops will be supported by the establishment of a community of practice for demonstration staff within the department, within which expertise can be shared as a communal body of tacit knowledge is captured and made explicit, resources can be gathered and the integration of the coursework supported by bringing together the previously isolated non-teaching staff members acting as 'demonstrators' during coursework sessions (Wenger 1998). This community will be supported by the use of a virtual learning environment (VLE) similar to that used by the TfLN (and described in Carmichael and Irvine, 2007).

The demonstrator staff community will be supported in turn by use of a Virtual Research Environment (VRE) offered through 'CamTools', based on the Sakai Virtual Collaboration Environment as described in Irvine and Carmichael 2007. This site currently contains information about both effective demonstration teaching techniques and specific examples and tips for certain labs; the emerging demonstrator community will be supported in using the site as a focus for continuing co-constructive activity.

The first cohort of second year undergraduate students has now completed the series of integrated coursework sessions and the following 'extended exercise'. Evaluation activities are being planned along the same lines as the initial research agenda in order to assess the impact



of the new development to ensure that it meets all of the requirements emerging from the research in the Department. This evaluation will also be used to inform future developments within the Engineering department, and feed back into the future development of the TfLN community.

References

Biggs, J., (1999), *Teaching for Quality Learning at University*, SRHE and Open University Press

Burt, R.S. (2005) *Brokerage & Closure. An Introduction to Social Capital*. Oxford: Oxford University Press.

Carmichael, P., Irvine, N. Jordan, K., Johnstone, K., Tracy, F. and Truscott, H., (2006) Enhancing Small Group Teaching in Plant Sciences: A Research and Development Project in Higher Education, Paper Presented at the Annual Conference of the British Education Research Association, University of Warwick, 6-9th September 2006

Carmichael, P., Irvine, N., and Tracy, F., (2007) Developing a Research Community in Higher Education from Student Feedback to Knowledge Construction. Paper presented at EARLI conference, August 2007.

Garsten, C. (1999) Betwixt and between: Temporary Employees as Liminal Subjects in Flexible Organizations. *Organization Studies* 20 (4), pp. 601-617.

Hill, T. (2007). Archimedes' Point: An Educational Research Body as Interface of Engagement. Presented at the Annual Conference of the Society for Research in Higher Education, Brighton, 11-13 December 2007.

Lave, J., and Wenger, E., (1991) *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.

Tracy, F., Jordan, K. and Johnstone, K. (2007). Reshaping Academic Practice and Relationships within the Department of Plant Sciences. Presented at the Annual Conference of the Society for Research in Higher Education, Brighton, 11-13 December 2007.

Trigwell, K. and Ashwin, P. (2003). *Undergraduate Students' Experience of Learning at the University of Oxford*. Oxford: University of Oxford.

Turner, V (1982) *From ritual to theatre. The human seriousness of play*. New York: PAJ Publications.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning and Identity*. Cambridge: Cambridge University Press.

