

‘We’re engaged’: Mechanical engineering and the community

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Abstract

Mechanical engineering programs, like other professional fields of study, have long been expected to be relevant to the needs of their related industries. In a context like South Africa, university programs are also expected to contribute to the country’s development needs. In an effort to address these new requirements, the coordinator of a mechanical engineering program invited community-based clients and organizations to set briefs for final (fourth) year engineering students’ projects. The community-based clients consulted with students during the process of project development, and were part of an assessment panel that awarded marks for the students’ work. The data for this study were obtained from observations of interactions between students, engineering faculty, tutors and clients, as well as pre-program, mid-program and post-program interviews with all participants. The findings of this study indicate that academic-community engagement in an engineering context required engineering faculty and students to develop new forms of knowledge, adapt existing practices, and build new professional and academic identities. The chapter offers an analysis of the difficulties and possibilities when new requirements are accommodated within existing ways of knowing, doing, and being in a mechanical engineering department.

Introduction and context

Mechanical engineering is a four-year undergraduate program in South Africa; traditionally the final year students complete a large project that is intended to integrate several areas of knowledge. Usually such projects are simulated ones, given by faculty to students as a “high stakes” assessment task. In this case, there were real clients and real projects. The program coordinator had invited community-based organizations, located in contexts that were familiar to most students, to develop briefs for the final year student projects. Students worked in teams to prototype machines, as specified by their community-based clients. Client 1 was a private client, a disabled cyclist who challenged the students to develop a competitive hand cycle. His intention was to buy the best prototype and to have it professionally manufactured for his own use in cycle races. A non-governmental organization, Client 2, had two projects: an all terrain trolley (to be used in informal settlements for garbage collection and recycling, and a can crusher (to be used by unemployed people collecting aluminum cans for recycling). Client 3 represented an energy-saving non-governmental organization that commissioned the students to develop an environmentally-friendly generator for use in areas with little or no access to electricity.

The final year project was intended to build students' knowledge and develop their engineering skills. By including community-generated projects, the engineering faculty also hoped to promote students' civic responsibility and encourage reflection on the connections between human, technological, and environmental needs. Including real-world projects was a departure from the norm for undergraduate projects, where design, prototype, and appraisal cycles were based on closed design problems that were faculty-assigned and usually unrelated to matters of community development.

The field and legitimation claims of mechanical engineering

Legitimation Code Theory (LCT) (Maton, 2007; Christie & Maton, 2010) is used as a language of description to analyze the collaboration between the academic department and community-based organizations. LCT provides an approach to understanding how different knowledge systems (e.g., academic and professional knowledge systems) can be shown to have a relationship to each other. Differences between knowledge types is not necessarily an impediment to collaboration; by analysing academic and professional forms of mechanical engineering knowledge in terms of LCT we are able to understand the different criteria for different legitimation claims – without necessarily closing off the different knowledge systems from each other. At the same time, LCT enables an awareness of power differentials and differences. Most importantly LCT recognises the importance of the relationship of knowledge claims between and across fields.

LCT is premised on an understanding that every claim to knowledge is a) about something, and b) made by someone. Knowledge claims can thus be located along an epistemic and a social axis. In mechanical engineering the “epistemic relation” is the relationship between mechanical problems/solutions and the knowledge system that purports to explain it; while the “social relation” is exemplified by the way in which an engineer mediates engineering knowledge for a client. In the academic world of the mechanical engineer, the epistemic relation is dominant, while in professional practice the social relation increases in importance. LCT can serve to accentuate differences between what, and how, those in universities and those in professional practice know, thereby providing a way in which each may better understand (and critique) the other. From enhanced understanding develops the possibility of mutual, rather than one-sided, recontextualisation, resulting in new insights into knowledge forms.

Mechanical engineering as an academic discipline: the epistemic relation

Mechanical engineering is the oldest of the engineering disciplines; it has been part of university structures for about a hundred years (Reid, Dahlgren, Petocz & Dahlgren, 2008). Mechanical engineering is typical of the “hard applied” disciplines (Biglan, 1973) in its application of the “pure” disciplines of mathematics and physics to the solving of mechanical problems. In the terminology of Bernstein's categorization of dichotomous ideal types, mechanical engineering has a predominantly “hierarchical knowledge structure” (Bernstein, 2000). The field of mechanical engineering develops through the extrapolation, integration and synthesis of previous engineering knowledge. In mechanical engineering, precision, accuracy, systematic thinking, and orderly processes and procedures are important criteria for the validation of knowledge (Carvalho, Dong & Maton, 2006). General engineering skills, such as conceiving models for problems and

solutions, setting up and conducting experiments, and applying design and simulation tools, are important for research and knowledge production (e.g., rapid prototyping, smart materials, and computer simulated machines). In its academic form, mechanical engineering exemplifies what Maton (2007) has called the “knowledge code”: a strong epistemic relation (i.e., the importance of physics, mathematics, mechanics and the properties of materials in solving mechanical problems) and a weaker social relation (i.e., the personal attributes and qualities of those applying the knowledge base).

Mechanical engineering as professional practice: the social relation

As a professional practice, mechanical engineering has significant differences to mechanical engineering as an academic discipline. While the “knowledge code” remains fundamental to engineering practice, it has to be mediated by what Maton (2007) calls a “knower code” that requires the professional engineer to mediate knowledge for a particular client within a particular context. Mechanical engineering as a practice thus moves from its hierarchical form towards what Bernstein (2000) calls a horizontal form “typified as ... context dependent, tacit, multi-layered...”. Hierarchical knowledge systems aim “to bring a broadening base of empirical phenomena within the purview of a decreasing number of axioms and develop through the integration and subsumption of previous knowledge” (Christie & Maton, 2010). Mechanical engineering in practice has developed conventions and procedures that derive their coherence from their contextual effectiveness, rather than from their internal knowledge system. A “project” is universally understood in professional engineering practice as a “unit of work”, usually defined on the basis of the client (Mills & Treagust, 2003). Almost every task undertaken in professional practice by an engineer will be in relation to a project (Baird, Moore, & Jagodzinski, 2000). Work-based projects will have varying time scales, levels of complexity, and will often be done by multidisciplinary teams, including engineers from different specializations, other professionals as well as non-professional personnel and teams, but all will relate in some way to the contextual coherence of the project.

Teaching and learning in mechanical engineering

The aim of undergraduate mechanical engineering programs is to graduate mechanical engineers who have a broad knowledge of both the timeless pure disciplines (physics, chemistry, and mathematics) and the newer applied disciplines (mechanics, fluid dynamics, and properties of materials) that make up the core curriculum (DeBartolo & Robinson, 2007). Learning in mechanical engineering demands the progressive mastery of concepts and techniques in a linear sequence. The “lecture-demonstration” (also known as a “demo”) is an important part of undergraduate pedagogy; faculty staff, often with the assistance of a technician, demonstrate problem-solving, show students how to apply knowledge of physics, mathematics, and a range of procedures and techniques, in the design of machines. Much of engineering problem-solving involves “translating” engineering problems into mathematical or scientific models. The lecture-demonstration program introduces students to definitions, concepts and theories; it illustrates related working methods, strategies, algorithms, heuristics, lines of thought, and contextualizes them. Students usually begin independent work on smaller mathematics- and physics-based problems before they are introduced to the world of machines in the workshop (Schmidt & Moust, 1998). Thus students both work through problems themselves, and

observe expert problem-solving to build their understanding of strategies and heuristics in action (Schoenfeld, 1985).

In the engineering disciplines, problem-based and project-based forms of learning are commonly used to encourage students to apply knowledge learned in the lecturer-demonstration, or from texts, as well as skills acquired in the workshop, to solve new problems. Project-oriented study, involving the use of small projects within individual courses, progressing to a significant final year project is common in engineering studies (Heitmann, 1996). Such projects will usually be combined with the traditional lecture-demonstration method within the same course. Projects thus focus on the application, and possibly the integration of, previously acquired knowledge. Students usually work on their projects in small groups with a project team of tutors and lecturers. Projects are undertaken throughout the length of the course and vary in duration from a few weeks to an entire year. Participation in projects in which students develop a design concept, build a system and test it, prepares students for professional project work. Participation in project work also enables students to practice and integrate the “soft skills” of communication, teamwork and time management with experimentation and machine design (Perrent, Bouhuijs & Smits, 2003).

University-based projects tend to be different from work-based projects because they usually involve only one area of engineering specialization. Faculty-developed problems and projects are selected on the basis of the course material. An important difference between professional engineering and student projects is the time scale of the real life problem-solving process: designing a machine in real life takes considerably more time than designing a machine as an engineering student project. It is assumed that successful completion of projects requires the integration of all areas of an engineering student’s undergraduate training.

From the description above, three basic forms of mechanical engineering can be identified, each with different emphases and areas of focus, although all working within the same knowledge system:

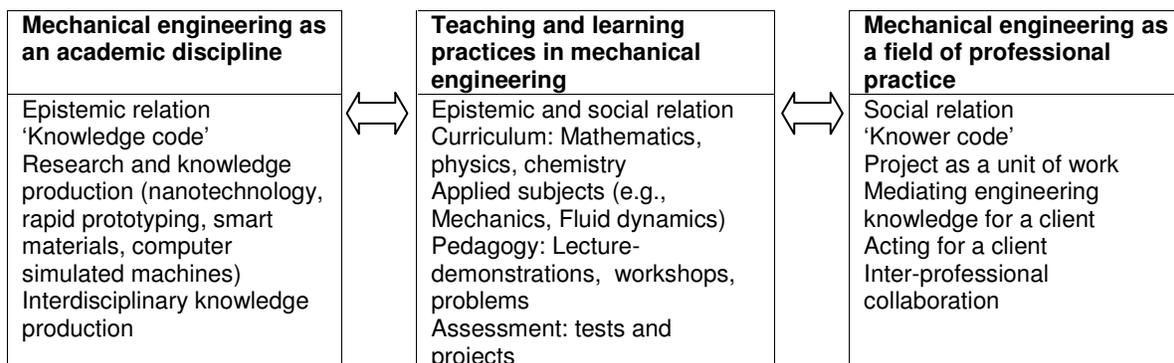


Figure 1: Relationships between traditional teaching and learning practices, the academic discipline and professional practice in mechanical engineering.

From the concepts developed thus far, we can construct a model of engineering education as striving to balance its vertical, “academic” form (the “knowledge code”) with its horizontal expression that is more common in professional practice (the “knower” code): the academic gaze recontextualising specific engineering problems, and practical problems necessitating the recontextualisation of academic engineering knowledge.

In the next section an engineering-community partnership is considered as particular form of recontextualisation.

The field and legitimation claims of community engagement

Governments around the world are concerned that universities provide opportunities for students to engage with communities, develop civic and social responsibility and apply what they have learned in their studies to address “real world” concerns in partnership with communities. An emerging body of research into community engagement suggests positive outcomes related to student learning, motivation and civic responsibility. At the same time interest in community engagement and service learning have re-opened debates about higher education for the public good (e.g., Harkavay, 2005; Chambers, 2005).

Community engagement in South African higher education has had a hybrid past, made up of elements of the anti-Apartheid struggle, influences from US-based “service-learning” and volunteerism, Gibbons and colleagues’ (1994) and Nowotny and colleagues’ (2001) conceptualization of a “Mode 2” society (Muller, 2010). For the South African Ministry of Higher Education, community engagement provides universities with opportunities to demonstrate their legitimacy and accountability to communities as a scholarly activity (e.g., South African Council on Higher Education, 2006). As a means of promoting civic responsibility among students, there has been interest in developing university-based learning that is more situated, participative, and community-oriented. Many academics are, however, concerned that both the conceptualization and practice of community engagement lacks intellectual rigor (Hall, 2010). Individual institutional approaches to community engagement vary significantly and the ability of higher education programs to foster community development is largely dependent on the degree to which disciplinary, curricular, pedagogical and assessment arrangements are compatible with the processes of addressing community needs.

Researching university/community interaction

In an effort to address the institutional requirement that all students to participate in a “community engagement” project, the coordinator of a mechanical engineering programme invited community-based organisations to set briefs for final year (4th year) engineering students’ projects. The research study, on which this chapter is based, was built around this intervention for the purpose of evaluating its effectiveness in terms of student learning. The “community engagement” project was seen to have three phases: 1) a pre-program planning phase (in which faculty and clients met to negotiate the terms of the client briefs); 2) an implementation phase (in which the students met with their community-based clients and addressed the briefs); and 3) a post-program phase in which all project participants met to “debrief” and suggest improvements for future work.

Observational data, using video- and audio-recordings, were obtained from the interactions between students, their lecturers, tutors and clients throughout the three phases of the project. Semi-structured interviews, based on initial analyses of the observational data, were conducted with engineering faculty, tutors, clients, and students at the pre-program, mid-program and post-program phases. In cases where faculty staff or clients were unavailable for interview, they were sent the interview questions via e-mail, and an e-mail archive of responses was included in the data. Also included in the data were the mechanical engineering students' reports and technical drawings that were prepared as part of their assessment. The students' oral presentations that were made to an assessment panel of mechanical engineering faculty and community-based clients were video-recorded. Field notes were made at a post-presentation "debriefing" between faculty, tutors and students. This research design was intended to provide data from all participants at different stages of the program, in order to study the extent to which the participants had similar or different expectations of the project, as well as to determine whether or not the expectations of the different groups were met, and secondly, to obtain data from a variety of sources (participants, students' work, e-mails, etc.) in order to obtain multiple views and understandings.

The findings are presented in terms of the three phases of this study: pre-program, mid-program and end-of-program, acknowledging that overlapping concerns were raised by participants at the various stages (e.g., during the assessment a number of planning issues were raised).

Pre-program: great expectations

Before the start of the project, lecturers, tutors, clients and students were asked the question: "What are you hoping to achieve in the university-community collaboration?" For faculty, the expected benefits had to do with developing students' ability to solve mechanical problems; the primary intention for the project was thus student, rather than community development. Engineering faculty were concerned that the students should demonstrate their engineering knowledge and abilities:

Community needs are often fundamental ... but nevertheless [pose] huge challenges for basic quality-of-life issues ... like water accessibility and treatment that requires technical intervention and 'real' engineering ... there shouldn't be a problem in finding appropriate projects that will test students' knowledge of engineering ... (Lecturer 1, pre-program interview).

It would later emerge that "finding appropriate projects" would prove to be a key difficulty. For faculty the main purpose of the university-community projects was the quality of the engineering in the final products produced by the students.

Tutors were more concerned with the quality of the learning process. They were particularly concerned about the additional support that students would require in undertaking client-driven projects:

My experience in community-based projects can be almost directly translated to express the kinds of skills that are needed in the private sector: project management, setting specifications, design and implementation, cost estimates, etc. Such a complete experience is difficult to achieve within a practical university project, in my experience as a student. It's going to be a good experience for the students, but difficult for them to manage all the elements of the project (Tutor 1, pre-program e-mail).

The clients participated in the collaboration with the understanding that their organizations would benefit from project. They hoped for more than a routine application of engineering knowledge from the students; their expectations of soon-to-be-graduates was that they should be at the cutting edge of knowledge and innovation in their discipline:

We can make adjustments from the point of view of usability and practicality ... what we are looking for is a great idea (Pre-program interview, Client 3).

The students misjudged the extent to which their clients valued innovative solutions to their technological problems. Students entered into their projects with enthusiasm, but not with thoughts about meeting specific engineering-based assessment criteria. Their expectations were that they would be able to use their existing knowledge and skills to benefit communities.

Mid-program: reality check

Work on the projects took place over an academic term (approximately six weeks); during this period the student teams worked with their tutors, under the supervision of a senior faculty member.

While noting the advantages for students to apply engineering knowledge in context, faculty expressed concerns about the academic level of the students' work. The difficulties of addressing clients' needs also became more evident as the projects developed. Most of these difficulties had to do with the different aims, practices and structures of academic demands versus clients' requirements. As Lecturer 2, expressed it:

Even though [the students] are trying to address the client's brief ... it's important that they also include methodical work on problems ... formulating hypotheses for possible solutions ... and ... synthesizing partial solutions for ... the original brief ... so that they ... not only test and evaluate the prototype ... but they think about it scientifically (Mid-program interview, Lecturer 2).

The same faculty member remarked that:

Students are always ready to jump into application ... there is never enough preliminary research (Mid-program interview, Lecturer 2).

Using real clients' briefs for the students' projects in some cases created applications that were extremely complex (such as the generator project), and in other cases applications that were too simple for the students' level (such as the can crusher). The question asked by one of the members of the assessment panel is indicative of the confusion felt:

Should the student be awarded marks on the basis of meeting the client's needs... or on the basis of demonstrating his mechanical engineering knowledge and skills? (Assessment panel, Lecturer 3).

Tutors wanted to avoid underestimating students, while acknowledging that some students had little prior experience in working for clients. As one tutor commented:

It's important to acknowledge what students bring to the course...and to avoid adopting an 'empty vessel' perspective ... but ... at the same time ... some students are just at the beginning stages of [mechanical engineering] product prototyping ... skills and capabilities ... so how much to assume is a difficult question (Mid-program interview, Tutor 2).

One of the tutors explained the need:

... to do a lot of explicit teaching on a one-to-one basis ... because aspects that apply to some students won't necessarily ... apply to all students (Mid-program interview, Tutor 3).

For clients, an important part of the process was ensuring that there was regular communication between the student team and the community organization; the clients valued those teams that were committed not only to the problem-solving process, but to ensuring that they addressed the brief:

Students can know and give the 'right' response... but in a [community directed project] you assess what people do ... as opposed to what they know (Mid-program interview, Client 2).

The students' engagement with the clients was greatly assisted by site visits and meetings with client and potential users. These interactions helped them to understand the particular needs of the potential users of their products. One of the students commented that:

Interviews and meetings with the people affected are essential ... these people need to be 'in the loop' at all times ... so there are no surprises! (Mid-program interview, Student 1).

The interactions between students and clients also showed the students that there was a great need for their engineering skills in a developing country like South Africa, and this boosted their confidence in their engineering abilities. Many students reported that the

project inspired them to use their skills to create technologies that could enhance communities' quality of life:

I know for me it has shaped my goals as an engineer and helped me understand the way engineers in the private sector can ... and should interact with disadvantaged communities (Mid-program interview, Student 2).

Post-assessment debriefing: back to the drawing board

The client-generated projects provided the students with a clear sense of a product in process, including the fact that the final assessment was not the end of product development. After the assessment panel had judged the student presentations, there were continued interactions between the students and their clients around improvements to the products, as well as collaboration across the design teams. In one case the best two projects were selected by a client for further development by the students. Such collaboration is common in industry, as one of the tutors writes:

Because community-oriented projects are inherently about working in teams with other people, including non-engineers, they encourage experimentation and prototyping at an early stage. This benefits students through teamwork, increased development of prototyping skills, and an increased amount of time spent trying ideas instead of relegating them to paper. For many classes ... a first prototype will often be made at a smaller scale or with less specific material requirements than a final product, but it is a valuable experience in the design process and often highlights weaknesses or clarifies alternative possibilities. ... Community-oriented projects allow students an opportunity to be a part of the full life-cycle of a technology or several technologies. Not only are they responsible for mechanical design, but finding and meeting user specifications, doing cost analysis, etc. It seems for many students that this process opens up new ideas of what engineering is and what engineers can do (Debriefing e-mail, Tutor 1).

The fact that a project is client-generated does not imply that the client's or product users' needs will be met. In practice, most of the students' designs were practical rather than creative, while the clients had expected product innovation. One of the users of the 'can crusher' claimed that the students had not taken her specific requirements into consideration:

I would like to crush the cans with my foot ... such as with a foot pedal ... why didn't any of these students invent a machine that I can work with my foot?
(Community member and potential user of the 'can crusher' and observer at the oral presentation, translated from isiXhosa).

In the debriefing session the student team claimed that the above user's request came in too late in the development of their prototype and they could not change it. Faculty understood the value of project-based learning that involved students in community service meeting clients' needs, frequent meetings with the client, and re-designing as the

prototype progressed, even though, in most academic projects there are time constraints on re-design. The faculty member assigned to this group remarked that:

Re-designing has more to do with attitude than with the project (Debriefing, Lecturer 1).

As far as students were concerned, the community projects had been successful; the student groups expressed a strong sense of purpose and motivation; they felt that their reports had been carefully prepared and that they benefitted from interaction with community organizations:

The project method of learning forced us to learn more about our subjects and enabled us to develop solutions to a specific problem ... communicating these ideas to [the client] affected the final solution by combining all the knowledge we had gained into our design ... it was not until the presentation that I realized how much we had learned as a group (Debriefing, Student 4).

For faculty, engineering knowledge remained the dominant organizational principle for the assessment of students' knowledge. Students were awarded marks according to the traditional criteria for final year projects. Faculty understood the benefits of project-based learning, but felt that the community-based projects had not been successful in enabling students to demonstrate the solving of engineering problems. They felt that community engagement might be appropriate at an earlier stage of the curriculum, and that complexity of the project should be controlled by the lecturer, preferably without real clients. This position is summed up by Lecturer 2:

Move the community engagement project ... downscale it ... to a smaller project for third years (Debriefing, Lecturer 2).

Conclusion

Engineering knowledge is the basis for professional practice, but is different from professional practice. The community engagement project made clear how the professional practice of mechanical engineering is different from the acquisition of engineering knowledge. The community engagement projects initially blurred these distinctions because of the prevalence of project-work in engineering pedagogy; but as the community-based projects progressed, differences between academic-driven and community-driven projects became apparent. At the outset, faculty did not realize how difficult it would be to respond to needs and priorities that were outside of disciplinary and educational concerns, or to change their knowledge-based orientation to one of social and economic relevance. Moore and Maton (2001) point out that:

The organisation of knowledge within an intellectual field is not simply the way in which previously produced knowledge is arranged into some kind of order ... It is characterised by a principle that also regulates the manner in which new knowledge is produced and its form (Moore & Maton, 2001: 157).

Table 1 provides a summary analysis of the relationship between the epistemic and the social relation in the community engagement project. Mapping the relation in this way shows the different criteria for the different legitimization claims, and also shows that faculty and tutors' concerns were with the quality of student learning, while students and clients were engaged in addressing community needs (more or less successfully).

Table 1: Dimensions of the epistemic and social relation in the mechanical engineering/ community engagement project

EPISTEMIC RELATION: Mechanical Engineering in universities			SOCIAL RELATION: Mechanical Engineering in professional practice		
Emphasis on:	Indicators	Examples from data	Emphasis on:	Indicators	Examples from data
Curriculum: Engineering knowledge and engineering processes	Lecturers assume projects are similar to traditional engineering projects.	<i>there shouldn't be a problem in finding appropriate projects that will test students' knowledge of engineering</i> (Lecturer 1).	Professionalism and professional identity	Clients assume they are going to obtain 'cutting edge' ideas from the student teams.	<i>We can make adjustments from the point of view of usability and practicality...what we are looking for is a great idea</i> (Client 3).
	Tutors see the benefit for students' exposure to the 'full-life cycle' of a project.	<i>Community-oriented projects allow students an opportunity to be a part of the full life-cycle of a technology or several technologies</i> (Tutor 1).		Students felt that the projects shaped their identities professionals-in-training.	<i>...for me it has shaped my goals as an engineer and helped me understand the way engineers in the private sector... should interact with disadvantaged communities</i> (Student 2).
Pedagogy: Teaching and learning engineering knowledge and processes	Lecturers are concerned with quality/content of learning	<i>... it's important [that the students] also include methodical work on problems</i> (Lecturer 2).	Relationship between engineers and clients, acting for a client	Clients valued students' commitment	<i>...in a [community directed project] you assess what people do ... as opposed to what they know</i> (Client 2).
	Tutors are concerned with students' different levels, abilities and learning needs	<i>[I need] to do a lot of explicit teaching on a one-to-one basis... because aspects that apply to some students won't necessarily...apply to all students</i> (Tutor 1).		Students saw the need for regular consultation with clients	<i>Interviews and meetings with the people affected are essential ... these people need to be 'in the loop' at all times</i> (Student 1).
Assessment: Demonstration of engineering knowledge and engineering processes	Lecturers are concerned that the engineering knowledge applied was not at an appropriate level of difficulty.	<i>Should the student be awarded marks on the basis of meeting needs ... or on the basis of demonstrating his mechanical engineering knowledge and skills?</i> (Lecturer 1).	Quality of product, meeting clients'/ users' needs	Clients were pleased when their needs were met; disappointed when their needs were not met.	<i>There were useful ideas from all three teams – they now need to work together on the best ideas</i> (Client 1). <i>... why didn't any of these students invent a machine that I can work with my foot?</i> (Potential user).
	Tutors understood that students	<i>[Students learned] the kinds of skills that are needed in the</i>		Students felt that they had learned both academic	<i>The project method of learning forced us to learn about our</i>

	were learning professional skills	<i>private sector: project management, setting specifications, design and implementation, cost estimates, etc.</i> (Tutor 3).		content and had represented clients' needs in the final product.	<i>subjects and ... develop solutions to a specific problem ... combining all the knowledge we had gained into our design... it was not until the presentation that I realised how much we had learned</i> (Student 1).
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The differences between the epistemic and social relation shown in Table 1 does not imply that the different knowledge systems should be isolated from each other. Ways of knowing, doing and being in mechanical engineering departments were acquired over many years; in new contexts, and for new purposes, the existing knowledge base (mechanical engineering) and its associated curricular, pedagogical and assessment practices (academic-driven projects, team-work, demos and academic presentations) are unlikely to be immediately useful to community-based collaboration, nor is community collaboration likely to immediately benefit student learning in engineering. The engineering faculty, in particular, experienced difficulties in crossing the boundaries between academic work and meeting clients' needs. Boundary crossing requires shared meaning making among groups. Tuomi-Gröhn and Engeström (2003) explain that when different groups work together, common understandings are necessary to ensure reliability across domains. Translation, negotiation, and simplification are required when the academic world and the real world meet.

The difficulties experienced can be expressed in terms of the distance between the existing and the new epistemic and social relation. When the new epistemic relation (the development of socially useful machines), and the associated social relation (service to a developing community) is very different from the existing epistemic (engineering-as-science) and social (engineers-as-professionals) relation, implementation and up-take are unlikely to be successful.

These findings have implications for collaborations between academic departments and the communities they (ultimately) serve. The alignment of engineering expertise and community interests and needs, as well as the extent to which there is compatibility between existing repertoires and new requirements (or the extent to which new requirements can be accommodated within existing practices), would be indicators for successful collaboration. Misalignment of these interests might provide useful learning experiences (as in this study), but the products of students' learning are unlikely to be valued by the academic department or taken up by a community, at least in the short term.

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