The evolution of an Engineering Communication subject -
learning theory through practice

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Abstract: The increasing recognition of the complex communication challenges facing engineering practitioners has meant that although the subject Engineering Communication has run at the University of Technology Sydney for many years it has continued to evolve. The current change, outlined in this paper describes our move from teaching the students to use a variety of communication genres while learning about human communication issues, to learning about communication issues through communicating and reflecting on that communication behaviour. Changes have been made in subject outcomes, the lecture component, the teaching strategies to support facilitation rather than transmission models of teaching, the assessment scenario, the teaching and assessment of processes for effective collaborative group work, the number of formative assessment tasks, the support of and opportunities for reflection on learning, and the inclusion of a technical sketching component. These changes are described in terms of the pedagogical issues underpinning them, and a number of examples are given.

Keywords: learner centric education, engineering communication skills, group work

Introduction

Engineers need to communicate effectively with their colleagues, competitors, clients, managers, workshop and site workers, the public, in multi-disciplinary teams (Engineers Australia 1999) and to advocate engineering as a viable profession. To develop such skills in our undergraduate engineers at the University of Technology Sydney (UTS), the six credit point core subject Engineering Communication has run for many years. It covers basic communication skills for engineers but also grounds these skills in an engineering workplace setting (McGregor et al. 2000). Undergraduate subjects evolve as a result of staff changes and pedagogical research. In autumn semester 2004, this subject has been restructured to explicitly address a number of pedagogical issues that have previously been implicit in the teaching activities but often not transformed into student learning.
Pedagogical Changes

In line with current research, the practice-based approach at UTS is grounded in the recognition that vocational and professional skills are best learnt through contextualised, meaningful participation. Research on the social construction of knowledge, communities of practice and situated learning (Lave & Wenger 1991) that allows for experiential learning in the context of use, states that a deep approach to learning will result if accompanied by reflection. Kolb’s experiential learning cycle (as cited in Jaques 1984 p.xii) suggests that we learn best when we are personally and actively involved in the learning process and that reflection is integral to this process. Brockbank and McGill (1998 p. 85) agree but suggest that using an ‘internal’ dialogue to aid reflection is no more than a preliminary step, for this reflective thinking to be of use and for deep learning to take place, they propose that a reflective dialogue with others is also necessary.

How can these theoretical underpinnings shape a pedagogical approach to curriculum re-development of a communication skills subject that will enhance student learning and the transfer of knowledge and skills? The emphasis on a learner-centred mode of teaching requires a shift from a transmission model of subject delivery to one that may result in transformational learning - learning which involves changes in communication behaviour. If learning requires a participatory framework (Hanks as cited in Lave & Wenger 1991 p. 15) then a communication skills subject requires an emphasis on interaction, on learning through doing, on teaching content through process. In other words, communication achieved through the real need to communicate. Our pedagogical approach was determined by this rationale and we decided to focus on team-based learning, a contextualised ‘client-focussed’ assignment scenario, a reframing of the teacher’s role, and, more explicit assessment procedures with formative feedback and reflective practice tasks.

“Team-based learning programs provide the learning environment that is most similar to the evolving work environments that students are likely to experience.” (Gordon & Connor cited in Boud, Cohen & Sampson 2001 p. 81). Collaborating in group work processes emphasises interaction and simulates an engineering community of practice. Requiring the students to form multi-disciplinary teams further establishes this link to the ‘real world’ and engenders motivation and a sense of engagement. Furthermore, using a series of sequenced tasks to provide students with group work skills and to review group management processes shows students that this aspect is important and enables them to review and reflect on group behaviour (IML 2002). “In one sense the task is the means to the end of group process aims; in another the group process helps the completion of the task” (Jaques 1984 p. 67).

Although the assessment tasks for this subject have been scenario-based for many years, this year we have linked the scenario to a professional engineer in a real engineering environment. To encourage motivation within group work situations it is important that this scenario is:

- meaningful e.g. ‘client-focussed’
- easily allocated into sub-tasks
- relevant to the learning needs of each student
- achievable (IML 2002 p. 11).

For experiential learning in the context of use to occur the role of the teacher changes to facilitator and monitor. “While experience may be the foundation of learning, it does not necessarily lead to it: there needs to be active engagement with it” (Boud et al. 1997 p. 9). To
generate this active engagement and motivation we have to consider the factors that not only make students want to learn but also the teaching styles adopted. The teacher’s function is to guide, to demonstrate, and to teach content through process. An understanding of students’ learning styles and what motivates them is essential. The procedural and logically-sequenced tasks that we have incorporated reflect what engineering students encounter in other subjects and suit their generally analytical and logical approach to learning. Motivation is particularly challenging in a Communications skills subject for engineering students who may be passively resistant to writing and speaking in public. However, as Biggs asserts, if teachers can “teach in such a way that students build up a good knowledge base, achieve success in problems that are significant and build up a feeling of ‘ownership’ over their learning, motivation follows good learning as night follows day” (1999 p. 61).

A further aspect of motivation is ensuring that the students understand the learning goals of the assessment tasks. The assessment procedures and criteria must be explicit, the tasks must be do-able, and the feedback formative. Students should not be asked to perform in a vacuum, the teachers must clearly state their expectations and prepare the students for the tasks. The assignment outcomes should be included in the assessment marking sheets and available in the subject guide for students to use as a guideline. The feedback given in formative assessment is vital to instil a sense of progress in and sustain the engagement of the students. Contextualised, open-ended activities in which students negotiate, articulate and discover lead to enhanced learning situations. By facilitating these in an atmosphere in which reflection is a valued part of the learning experience, students are more likely to develop life-long learning skills.

**Changes in subject structure and delivery**

In the restructuring of the subject we have attempted to incorporate strategies that more explicitly support the pedagogical issues discussed above.

The major changes include:
- describing clear **subject outcomes** in terms of five simple communication concepts
- distilling the **lecture component**
- supporting **tutors as facilitators** of learning for learner-centred workshop approach for tutorial sessions
- providing a **scenario based** on a real engineering situation meaningful to all Fields of Practice with an engineer in that situation acting as consultant to the students
- embedding **collaborative group work** theories more explicitly in practice
- developing opportunities for more **formative assessment** strategies
- incorporating a series of **reflection** tasks
- providing a **technical sketching** component.

In the following section we describe each change in terms of the pedagogical issues and give examples.

**Subject outcomes**

The Subject Outline describes the subject outcomes in the following terms:

“In very general terms this subject is about communicating as an engineer. There are five very simple ‘four-letter-words’ that encompass the scope of communication covered: we would expect you to
improve and demonstrate your ability to **find, read, write, draw** and **talk** in engineering fields. Of course these five simple focus areas have very complex hidden depths in terms of the theory and practice of human communication” (University of Technology Sydney 2004).

Figure 1 (from the same Subject Outline) represents these five simple terms graphically as five logos that are used to identify all subject documents and web materials, thus making communication a more concrete, explicit, simple and cross-cultural concept. The inherent complexity of such seemingly simple terms is then elaborated upon. By couching all objectives, outcomes and learning activities in this way, students can better understand the reasons for many of their class activities and assessment tasks.

<table>
<thead>
<tr>
<th>Key words</th>
<th>What this means in terms of developing your engineering communication skills</th>
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<tbody>
<tr>
<td><strong>Find</strong></td>
<td>You will need expertise in finding information about a particular topic from a wide variety of sources - books, journals, magazines, web, experts, clients, the engineering workplace and many more. You will also need to demonstrate that you can evaluate the information you find in terms of its credibility and depth.</td>
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<td><strong>Read</strong></td>
<td>You will need to be able to read English and make sense of it. More importantly you will need to read critically to inform your secondary research (research of work done by others) - analyse the information you read, paraphrase it, synthesise ideas from a number of sources... Your work in Engineering for Sustainability will have given you a starting point for developing your skills in this area. You will also need to 'read' technical drawings and other forms of visual communication including tables, charts, diagrams, and many more.</td>
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<td><strong>Write</strong></td>
<td>You will need to write effectively in English. This means your writing must be easily read and understood by the audience for whom it was intended. It also means that you can write to demonstrate your ability to analyse and synthesise the writing of others as well as data generated from your own primary research (raw data found by you). You will need to develop writing skills in a number of genre and for a variety of different audiences.</td>
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<td>Collaborate</td>
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<td><strong>Draw</strong></td>
<td>You must be able to represent your ideas and plans visually in many engineering contexts. These contexts might range from sketching ideas on a bus ticket or serviette whilst meeting informally with colleagues or clients, to representing data in tables, diagrams, plans and graphs in formal engineering reports and presentations. You should also develop your ability to create meaningful visuals that include appropriate labels, captions and titles and are correctly integrated into your written work.</td>
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<td><strong>Talk</strong></td>
<td>This is perhaps the broadest of the five focus areas. You will need to be able to discuss ideas with clients and colleagues, present ideas in formal presentations and play an active role in work teams. To do all this effectively you will need to use theories of human communication to inform and improve your interpersonal communication style. Some of the human communication issues might include cultural understandings, body language clues, negotiation skills, communication management and many more. Listening to others and understanding their issues will mean you will need to develop your thinking skills to be able to develop creative ideas and accept the ideas of others.</td>
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**Figure 1. Complexities that arise from the five simple logos. (University of Technology Sydney 2004)**
**Lecture component**

In previous years, much of the subject content has been presented in lecture mode followed by a tutorial. In general, attendance at lectures has been poor and interest superficial. It is believed that the students found this teacher-focused transmission model of transferring/presenting knowledge both uninteresting and demotivating. The subject teachers recognised that a ‘surface’ rather than ‘deep’ learning approach to the lecture material was the result for most students. This concurs with the issues raised in an RMIT survey of second year Chemical Engineering students’ attitudes towards lectures and tutorials. The survey concluded that most students were dissatisfied with the traditional model (Jollands et al. 2003 p. 200). The most popular tutorial style was one in which the “development of skills was augmented by engaging with relevant questions and getting one-to-one help” (p. 197). This tutorial style also enables the tutor to assess individual learning styles and needs (p. 200).

Consequently, we have significantly reduced the number of lectures and content is now presented in tutorials based on a student-focused workshop approach with tutors as facilitators of learning.

Although this is a more expensive format for the faculty it is justified by being a more appropriate model for a ‘communication’ subject. The lectures that have been retained are those for which we have a guest practitioner with expertise in a field of communication and who is able to demonstrate communication skills in action through, for example, presentations on visual and group communication.

**Tutors as facilitators**

Moving to a more student-focused model requires that tutors are supported in moving from “Sage on the stage to guide on the side” (New Scientist 1994). To this end the workbook now has more explicit rationales and guidance, and is accompanied by a tutor’s manual. This manual and the weekly tutor meetings further explain the more learner-centred pedagogy and provide information on effective facilitation skills. To further enhance tutor awareness and encourage discussion, the tutors are rostered to present a workshop module in the weekly meetings. This input and feedback from the tutors is invaluable not only as a teaching tool but also to aid in improving the subject.

The new workbook is designed to allow for flexibility in the choice and order of module completion depending on the tutor’s understanding of the students’ learning styles and needs. This ensures that students are able to work at their own pace, allowing for a building of knowledge and skills onto those previously learned.

One important aspect of providing formative learning strategies is that students are facilitated to ‘see their mistakes as learning opportunities’. Progress must also be continuously monitored and feedback strategies employed to ensure that progress is achieved. To further enable students to work from their own communicative capabilities, they can choose to join the tutorial groups run by tutors from the English Language Study Skills Assistance (ELSSA) Centre. Although these groups, which tend to be selected by Non-English speaking background students, are presented with the same subject content, there is a stronger focus on the development of academic writing and oral communication skills and a more detailed drafting and feedback system is used.
Assignment Scenario
Motivation to learn is increased when students see a need beyond merely passing the next exam. If students see the learning situation as intrinsically important to them in real life their learning is less likely to be surface and short term (Biggs 1999 p. 60) and more likely to lead to life-long learning (Jaques 1984 p. 64). Thus the "situation" for learning should be perceived as truly real-life and not just devised to seem so. Biggs describes this as expectancy-value motivation because a learning task must be:

- important; i.e. it must have some value to the learner
- possible to do; i.e. the learner has to expect success (1999 p. 56).

Our current scenario is ‘Engineering in Antarctica’. Links have been established so that students can communicate with an engineer from UTS who is a resident at the South Pole for 12 months. Her diary and photo album are maintained at www.eng.uts.edu.au/links and she has access to our online learning platform for the subject. The ultimate task for the students is to produce a feasibility study of the issues that would need to be addressed if building a new Antarctic base. We feel this is more achievable by 2nd year engineering students than a more technical design report. They should find motivation for learning in being able to explore, develop hypotheses, test and retest at their own level. Moreover, this scenario simulates the engineering workplace by having students work in multi-disciplinary teams called Engineering Consultancy Groups.

In addition to writing an individual paper and a group work report using the scenario, the students give an oral presentation to the scenario ‘client’. As with the writing assignments the students are prepared for this through being prepared for and participating in a series of lead-up tasks. These mini-presentations, for which they receive peer and tutor feedback, further support the idea of learning communication skills communicatively.

Assessment
After considering the communication skills of the students (both the average and extremes) that enrol in our 2nd year Engineering Communication subject, assignments have been modified to an appropriate level for these students in terms of:

- **length** – a reduced word count means a need for more precise and concise writing. This is harder for students and an important lesson in communication. Limiting the word count also has the added benefit for tutors of less time spent reading, allowing more time to be spent giving meaningful feedback.

- **genre** – by including ‘summary’ or ‘précis’ as a genre, tutors are able to support learning of critical reading skills. A series of written activities sequenced in terms of difficulty early in the semester also better equips students to develop their skill in writing a synthesis.

- **technical knowledge required** – most students enrolling in this subject have limited technical knowledge in their engineering field and most have not yet experienced the engineering workplace. It is important that the content of their reading and subsequent communication about their reading is at a level that does not require a high degree of technical knowledge.

- **audience needs** – communicating to non-technical audiences about technical matters requires a much higher standard of communication skills than communicating with an audience of peers or tutors. The scenario has allowed us to focus on both types of audiences by including funding bodies, developers and users as the audiences for various tasks.
While marking sheets with explicit assessment criteria have been used for many years for assessment tasks in this subject, the criteria have often been interpreted differently by each tutor and student. While open-ended criteria allow for greater scope, students also need explicit information to inform them of the standards expected. These assessment criteria sheets reflect assessment of learning in the five focus areas outlined at the beginning of this paper as well as the product and process required to achieve it. This then allows for feedback and formative assessment of the skills and development issues that we feel are important rather than simply on how well the students write English.

**Collaborative group work theory made explicit**

Educational research as summarised in *Enhancing Experiences of Group Work* (IML 2002) shows that self-directed learning, peer learning, interpersonal skills and autonomy are fostered through team-based tasks. Collaborative learning occurs when students work in small groups towards a common goal using the qualities of the individuals within the group to achieve that goal. In collaborative learning there is an opportunity for the discussion of problems enabling students to communicate their learning and experience with peers. This “Formulating and articulating experience transforms it in ways that can allow us to see it anew” (Boud *et al.* 1997 p. 10) and leads to deeper learning as students view their knowledge and skills through the perspective of others.

There are five issues that may cause the failure of group work activities:

- The composition of the group is important so that a truly co-operative grouping of students is achieved and workload division is equitable.
- Students bring their previous group work experience with them. Unsatisfactory group work experiences may result in a negative approach and hamper learning. These experiences must be overcome for group work to be truly effective.
- Students are rarely given the appropriate tools to work effectively in groups.
- Unless group work skills are assessed students may consider them to be of little importance.
- “No understanding of group behaviour is sufficient for successful participation in groups unless each person in the group has the capacity to communicate effectively” (Jaques 1984 p. 45).

In the restructuring of the subject, group work theories are presented and practised throughout the semester in two different working groups. The ECG (Engineering Consultancy Group) and FPG (Field of Practice Group) are central to the scenario and provide a practice-based ‘jig-saw’ learning opportunity. Assessment has also been modified to include marks for group working processes. “By using questions that focus on teaming issues, the instructor also makes it clear that the course is as much about helping students learn about effective teaming as it is about producing a good final product” (Lewis *et al.* 1998 p. 151). As communication skills are learned very effectively through communicating and reflecting in groups, activities are presented that provide scaffolds for analysis of individuals and how they can best support the group. Students learn how to identify their individual team roles, their strengths and weaknesses and also those of the groups in which they work. They also learn strategies to address these issues, for example, they participate in activities designed to achieve the ‘forming’, ‘storming’ and ‘norming’ stages of group work (so often ignored when group work tasks are expected of students). They also learn how to manage their groups by completing:
- a Team Charter—including ground rules at the beginning of semester and a review halfway through
- checklists for meetings
- meeting agendas
- sequenced reflection activities.

**Reflection on learning**

Reflective practice and life-long learning skills are promoted through reflection on practice and formative assessment procedures. “Making reflective practice accessible to student learners, enables the latter to become more conscious of their own approach to their learning and thereby promote critically reflective learning via reflection on their practice and learning about their learning” (Brockbank & McGill 1998 p. 73). However, for this to succeed the teacher needs to be explicit about the intention of any reflective task and be able to recognise the process of reflection, relate to it and model it (Brockbank & McGill 1998 p. 73). This focus of reflection on the process and learning strategies involves helping students to develop a metacognitive awareness, an ability to think about the strategies they use to complete a task (Johns 1997 p. 13). Metacognition (thinking about thinking and learning processes) is the ultimate learning goal because it is transferable. It is achieved by developing the ability to evaluate learning situations and the learning achieved, then reflecting on how this learning will direct future activities and finally articulating this learning. It enables students to answer the ‘So what?’ question about the relevance of learning experiences and how they affect them as individuals.

This subject has previously had a summative examination or quiz to test material presented in lectures and texts. However, in the light of assessment of both product and process and in an attempt to develop metacognition in our students we have introduced a summative reflective task. Marks are awarded for breadth and depth of reflection rather than on positive and negative comments. It is important that there are no marks for the ‘correct answer’ but marks for the depth of the answer given. By developing reflection scaffolds through mini-reflection exercises in class throughout the semester students are expected to be able to provide a deeper reflective writing task at the end of the semester.

In the introduction to this task students are given the following information in the Student Outline: “Assessment of reflections is made on how you have reflected rather than what you have said. Therefore it is important that you reflect on:

- your progress and your past and current level of development of your engineering communication skills
- the positives and negatives of the process of your development both as an individual and as a member of a variety of groups
- your strengths and weaknesses
- the opportunities and trade-offs you had to face in the process
- the objectives of the course as stated in this Subject Outline and how you have developed outcomes that demonstrate your success in these areas
- the issues of human communication that you have addressed and will need to remember when working as an engineer and working with others.” (University of Technology Sydney 2004).

**Technical sketching component**
Within the faculty there has been much debate over the years about whether the subject Engineering Communication should cover any visual communication skills. It was decided that it was ‘inappropriate ... to teach sketching and drawing skills’ that were specific to any one field of practice (McGregor et al. 2002). In other words, students should learn about visual literacy rather than how to do specific graphic communication tasks. However, after much consideration, input from other staff, and research into the graphic communication skills of our 1st Year students, we are now trialling a technical sketching component within the subject. More details of this component are published in Jacobs & Brown (2004).

Conclusions

While at the time of writing this paper the restructured version of the Engineering Communication subject has been operating for only four weeks, it is felt that the focus of the subject is successfully changing from teacher-focused to student-focused. The understanding of the breadth of communication and the focus areas presented via the five logos is developing well. The students have formed their FPGs and ECGs and generally seem to be benefitting from the tools they are being equipped with. The students’ levels of maturity, motivation and commitment vary, and, as is to be expected, some are approaching the reflective practice activities more seriously than others. It is also too early to gauge the opinions of the tutors most of whom are new to the subject. We will be asking both the students and the tutors for quantitative and qualitative feedback at the end of the semester. Although it is impossible for any one student to compare the ‘new’ version with the ‘old’ version of the subject, as no student who understands communication has experienced both, students who have passed the subject previously and seen the redeveloped subject materials have commented positively on the changes.

References

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Acknowledgements

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