This paper identifies groups of generic skills that undergraduate engineering students need to develop as part of their education. We offer a model to improve the teaching of generic skills within an undergraduate engineering curriculum. A practical example of integrating of generic skills into an engineering subject is included.

Importance of generic skills for engineering students

A recent report (IEAust, 1996) on the effectiveness of engineering education urges that attention be given to ensuring that graduate engineers are equipped with skills that are additional to specific technical and engineering science skills. These include skills in areas of communications, problem solving as well as capabilities to organise information and understand business processes. The view that engineering students lack particular skills after graduation is not new. In 1992, a study commissioned by the Higher Education Council (HEC, 1992) had the following to say: “Our findings indicated that communication and social skills are the key skills requested by employers of both new and experienced graduates.” These skills and characteristics that employers have come to expect from qualified engineers can be grouped into what are called generic skills. Other authors such as Elliot and Anastasias (1996), Clanchy and Ballard (1995), Sleet, Hager, Logan and Hooper (1996) and BIT (1994) have also referred to the nature and importance of generic skills. They have also assisted in generating lists of generic skills.

Types of skills and attributes needed by engineering students

There are, broadly, two main learning and developmental purposes that a curriculum should address. These involve the acquisition of technical and generic skills.

Technical skills refer to specific competencies and capabilities that are relevant to a particular discipline. For example, a mechanical engineer needs specific knowledge about phenomena such as material strength, energy transfer, design standards and thermal efficiencies. These are specific skills needed to perform particular work responsibilities. Most of the content of engineering curricula appears to be strongly focused upon the acquisition of technical skills. The acquisition of specific technical skills can be easily measured with the aid of tests and examinations. However, technical skills may be lost through lack of exposure or sustained practice over periods of time. Moreover new technical skills are continually emerging, while some old skills become redundant.

Generic skills are capabilities that can also be learned, and are increasingly recognised as essential to enable people to perform effectively in work situations. These skills may be subdivided into groups of personal and interpersonal skills and attributes. They are, however, usually regarded as incidental and subservient to technical skills. Examples of generic skills include: problem solving, dealing with uncertainty and ambiguity, organising information, decision making, interpersonal communication, time management, study skills, and the awareness of ethical, cultural and ecological issues.

These generic skills are usually not formally taught as part of the engineering curriculum content, despite their outcomes being invariably sought after by employers and the public at large. Generic skills should be taught as an integral part of the learning activities of students and be assessed as part of the overall assessment of subject content. One particular group of generic skills which are less discernable and difficult to teach concern personal attributes or attitudes. These include such characteristics as honesty, integrity, ethical awareness, and a capacity for displaying initiative and responsibility. These characteristics are not formally taught, but when considered, can be indirectly addressed throughout the curriculum, especially with teachers acting as important role models.
Different views about generic skills

It has been suggested (HEC 1992) that generic skills refer to the idea that “knowledge is provisional ... and that no answer is final ...” This is true to the extent that all knowledge is organised within mental constructs that can change over time. Consequently, when people employ generic skills they use skills that support the application of subject specific knowledge. This is particularly relevant for engineering graduates who require an “ability to function effectively ... in multi-disciplinary and multi-cultural teams”, understand the “social, global and environmental responsibilities of the professional engineer”, have “commitment to professional and ethical responsibilities”, have the “expectation and capacity to undertake life-long learning”, and courses should pay “greater attention to problem-solving and the encouragement of creativity and innovation” (IEAust, 1996). This is particularly important in an area where discipline-specific skills often become quickly obsolete given the rapidly changing nature of technology and the workplace.

Engineering students have also expressed views about generic skills. For example it was reported (SUT 1997) that first year engineering students acknowledged the importance of generic skills such as the need to develop their organisational and time management skills and to improve the quality of learning through the formation of collaborative groups. However, it appeared that many failed to appreciate some of the implications of these skills, such as the need to learn independently of the tutor.

Compiling a meaningful list of generic skills

It is quite absurd to attempt an exhaustive list of generic skills: it is a list without end. Also, a comprehensive list would be impossible to implement at any stage of a curriculum. What is needed is a list of the most important skills which should be given immediate attention. What follows is a working list that covers all the essentials of lists previously encountered.

Our list of generic skills is divided into four categories under the headings of:

Organisational skills

- **O1** Accessing and managing information
- **O2** Setting goals and monitoring progress
- **O3** Time management and meeting deadlines
- **O4** Adapting to new situations

Interpersonal skills

- **I1** Listening and passing on instructions
- **I2** Written and oral communication skills
- **I3** Working in teams
- **I4** Concern for health and safety of people

Cognitive skills

- **C1** Defining problems and evaluating alternatives
- **C2** Decision making
- **C3** Imagination, abstract thinking and self learning
- **C4** Appreciation of interdisciplinary nature of subject content

Attitudes

- **A1** Self-confidence and initiative
- **A2** Ethical awareness and social responsibility
- **A3** Respect for culture and heritage
- **A4** Concern for ecological and environmental issues

An important consideration is whether generic skills should be taught as stand-alone subjects, or incorporated appropriately into the specific engineering subjects. One serious argument against offering specific “generic skill” subjects is that students often fail to see their relevance. In addition, there is the question of who would best teach generic skills? These skills will only be legitimised if they are taught as an integrated part of the subject matter by the subject teacher, perhaps with some professional development and certainly with some guidance as discussed in the IEAust (1996) report.
Learning experiences and activities

According to Tyler (1973), a learning experience refers to the interaction between the learner and external conditions within the environment in which the learner can respond. Learning is largely a result of student activity which focuses their interest and motivation and finally enables meaningful learning to be achieved. Learning experiences relate to the actual conscious involvement of a students within the learning environment. It is within the framework of appropriate learning experiences that generic skills can be developed.

Rather than referring to learning experiences, we prefer the term learning activities. A list of potential learning activities which is neither exhaustive nor mandatory is set out below:

- Lecture/tutorial with student participation
- Topic notes - made by students from tightly given guidelines.
- Laboratory experiments - designed and carried out in small groups and in the traditional discovery method.
- Computer managed learning (CML)
- Literature search or case study
- Poster presentations - depicting an industrial/commercial process.
- Interview - with industry/commerce person
- Tutorial problems - submitted for peer assessment
- Class test(s) and final examinations
- Investigating previous examination questions
- Compiling and answering questions developed and solved by students
- Open Day - participation in preparation and officiating.

Efforts to facilitate learning of generic skills

We analysed a number of first year engineering subject to identify whether generic skills were being addressed. For example, we compiled a list of generic skills in relation to Engineering Physics, which is a compulsory subject taken by all first year engineering students at Swinburne University. The outcomes were informative and surprising. It soon became evident, that certain generic skills such as: Concern for health and safety of people, Ethical awareness and social responsibility and Respect for culture and heritage, Concern for ecological and environmental, were not addressed at all. This was not surprising since Engineering Physics is a first year service subject focusing on fundamental science rather than the practice of engineering. However, the limited appearance of generic skills which we believe are important for physics, such as Defining problems and defining alternatives, Imagination and abstract thinking and Self learning was surprising and of concern.

Specific review of generic skills

What follows is a review of a group of generic skills. It is not the intention to relate learning activities to all the skills, but rather to focus initially on a few generic skills at a time and get those ‘right’. Any additions and changes to the subject may involve any or all of the existing content and the actual delivery or assessment. An analysis is presented in Table 1 and refers only to four generic skills (O3, I2, I3 and C3) as applicable to Engineering Physics.

Implementation of a method to address generic skills

A most important requirement for integrating generic skills into the curriculum is to obtain the support of the teaching staff. This is not easy, especially with limited resources. If staff feel uncertain about how to address generic skills, or find that they become overburdened with additional assessment, they may revert to teaching only technical skills and ignore generic skills.

To provide guidance to staff, each subject should be supplied with a syllabus guide in addition to the formal syllabus, consisting of:

a) Aims of the program
b) A complete list of generic skills
c) A list of potential learning activities as illustrative examples
d) A copy of Table 1 or its equivalent which contains selections from the list of generic skills.
e) A copy of the implementation procedure.
f) A means of assessment and feedback from students.
The syllabus guide can be incorporated into a specific subject information guide together with other relevant items, such as detailed aims and objectives, assessment criteria, specific instructions, laboratory requirements and deadlines. Irrespective of whatever else students are given, it is essential that they are continually made aware of the importance of generic skills to their chosen profession, and our efforts to integrate them into the course.

<table>
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<tr>
<th>Generic Skill</th>
<th>Possible Learning Activities</th>
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| O3 Time management and setting deadlines | **Tutorial problems:** submitted for marking twice during each semester with the date and time being set at the beginning of the semester.  
**Laboratory assessment:** CML and report book required two weeks after the laboratory class resulting in a cumulative mark.  
**End of semester examination:** requiring students to be able to deal with time constraints and revision timetable.  
**Poster presentation:** students compile a poster depicting a scientific or natural phenomenon or industrial process.  
**Literature search:** where students identify a specific problem related to some issue and gather relevant scientific information about how others have addressed the problem. This information may be reported in written or verbal format. |
| I2 Written and oral communication skills | **Tutorial problems:** see above.  
**Laboratory experiments:** carried out in small groups.  
**Literature search:** see above  
**Topic notes:** as an outcome of formal topic presentations or from tight guidelines, students compile short notes which serve to cover the main issues under consideration. (The compilation may be subsequently assessed).  
**End of semester examination:** In addition to testing technical competency, attention is also given to student’s communication skills.  
**Compiling and answering questions:** students compile questions related to particular open-ended topic issues and proceed to provide appropriate answers. |
| I3 Working in teams                     | **Laboratory experiments:** done in small groups.  
**Literature search:** see above.  
**Literature search:** see above.  
**Poster presentation:** see above.  
**Compiling and answering questions:** see above. |
| C3 Imagination and abstract thinking    | **Topic notes:** see above.  
**Laboratory experiments:** see above.  
**Literature search:** see above.  
**Poster presentation:** see above.  
**End of semester examination:** in addition to the above, these also involve problem solving and concept testing.  
**Compiling and answering questions:** see above. |

Use of the syllabus guide

The syllabus guide should contain some examples of student assignments that refer to the specific content of the envisaged learning activities. For example, if the intention were to have students compile a literature search, this could be worded in the syllabus guide as follows:

*Conduct an investigation into one of the following topics and report your findings in both written and oral format:*

*How was thermodynamics first described?*

*What practical applications concerning thermodynamic principles were first used?*
Who were the first people to devise and use thermodynamic concepts and what are these concepts? How have particular applications of thermodynamics changed since first used?

Another application may be in respect to getting students to compile a poster and to this end the task may be set out as:

Compile a list of possible practical applications of thermodynamic principles and present your findings through the use of a poster. Select one of these practical applications and describe the operation and processes involved. The criteria will include:

Professional appearance of poster.
Objectives of poster.
Clarity of process description.
Indication of effort involved in producing the poster.

These would be included in the syllabus guide as illustrative examples, for teaching staff to use as indicated or suitably adapted. They would also be expected to develop other appropriate assignments.

Feedback and assessment

An essential part of the program will involve assessment of student performance and perception of generic skills. This should be conducted on two levels. The first involves assessment of student achievement, including allocation of marks for particular generic skills such as written communication. The second involves feedback from students on the importance they attach to generic skills, their perceived level of competence achieved, and how well the subject addressed generic skills.

One way to achieve the latter assessment process will be through the use of a student questionnaire. Here, students will be provided with a questionnaire (using a Likert scale) at the beginning and end of the semester. An example of a questionnaire is shown in Table 2 and 3.

Throughout the semester, efforts should be made to conduct focus groups on an on-going basis to assess student development of generic skills. These responses and the teachers’ experiences should be documented and evaluated, and the ensuing changes integrated into the next semester’s round. This procedure would also greatly assist quality assurance processes. Also, students should be regularly reminded of the purpose of the subject which is not only to focus on the technical skills (important though they are), but also to address various generic skills.

References

BIT (1994) Bachelor of Information Technology: Development and implementation of strategies for assuring teaching quality and performance, Swinburne University of Technology, Melbourne.


Elliott, P. and Anastasias J., 1996, Addressing the issue of generic skills involved in undergraduate subjects and undergraduate majors, Swinburne University of Technology, Melbourne.


