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Embedding teamworking and teamskills into an engineering degree programme – various models

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***Abstract**: This paper discusses the authors' many years of experience in the delivery of alternate models for the engagement of student groups and their participation in teamskills development on both residential and in-house courses that serve to underpin degree programme activity. The paper reviews some of these alternate models, reflects on their relative merits, and discusses examples where graduating students have also given their own reflections on their experience of teamskills development. The examples are taken from programmes run at the University of Birmingham, and cover both undergraduate and postgraduate taught programmes.*

Introduction

Employers place great emphasis on a large portfolio of life-skills that they expect their newly-recruited graduate engineers to bring to their company from the outset; these skills are, of course, additional to the graduate's technological knowledge and abilities. Key and oft-quoted amongst these, is the ability to be a "team-player". There is an expectation that students will have acquired this skill during their degree programme, but it is a skill that needs to engendered and developed in the individual over time, preferably by embedding experiential opportunities into their programme of study.

Those responsible for the accreditation of engineering degree programmes have recognised and declared over many years that practising engineers should be competent in a diversity of professional skills – from the Finniston Report in 1980 on the engineering profession, through SARTOR to SARTOR3 in 1997 on Standards in Engineering Education, to UKSPEC in 2004, as summarised in (Fidler, 2003). UK-SPEC from the Engineering Council (Engineering Council, 2004a) identifies Threshold Standards of Competence and Commitment for both Chartered and Incorporated Engineers that includes "providing technical and commercial leadership… by leading teams and developing staff" (Engineering Council, 2004b). Degree programmes accredited by the Engineering Council under UK-SPEC specify Output Standards for accredited programmes, applicable to both MEng and IEng programmes (Engineering Council, 2004c). Team skills and teamworking is implicit throughout.

Employers should, therefore, expect graduates from accredited programmes to be at least conversant with the ability to work within teams. The challenge for higher education is to develop and adopt the most relevant approach to the embedding of that skill into their students' curriculum.

Background

The School of Engineering at the University of Birmingham currently comprises discipline areas in Mechanical, Civil, Chemical, and Electrical/Electronics Engineering, and Metallurgy and Materials. Each was formerly a School in their own right until 2002, and prior to this, Mechanical Engineering was the School of Manufacturing and Mechanical Engineering.

The School of Manufacturing and Mechanical Engineering has a long-standing record in recruiting large numbers of students to both its undergraduate and postgraduate taught programmes, offering joint and double degrees in Business, Commerce and Languages at undergraduate, and an integrated suite of management programmes, for example in Operations Management, Project Management, Management Systems, Operational Research, and Work Design at postgraduate Masters level. These modular programmes were structured on 10 and 20 credit courses, with 30, 40 and 50 credit projects.

The integrated suite of Masters programmes was originally established in 1989 from previous stand-alone programmes. The opportunity was taken to enhance the inter-connectivity between programmes and commonly taken modules, by the addition of a one-week intensive residential course in Team Skills and Management Development. The principal author had been responsible for establishing this suite, and worked with his team of Programme Directors to identify suitable venues.

The University of Birmingham owns its own outdoor pursuits centre (The Raymond Priestley Centre) at Torver, near Coniston in Cumbria on the shores of Coniston Water; this 40-bed, country-cabin style facility was chosen as the venue as it offered on-site skilled staff, the outdoor environment and classroom facility to practice team skills, and the Centre's prior experience in similar courses for other Faculties of the University (Law, Business, Geography, Sports Science) and other UK higher education institutions (HEIs).

The Teamskills and Management Development course

The aim of this 10 credit module was to develop students' teamworking skills, achieving this through the challenge of participating in team-oriented outdoor activities complemented by classroom development of underlying principles and thinking. The module was to be summatively assessed by a one hour exam (pre-specified by the Board of Postgraduate Studies), with students putting their experiential learning into the contexts provided by their classroom activity.

The course was set up to be 5 days duration with a daytime and related evening programme, and run twice-over (back-to-back) in order to accommodate the student numbers. Those not attending at Coniston had a Reading Week in Birmingham in preparation for their Masters project placement in industry. The daytime programme included canoeing and rafting, orienteering and hill-walking, climbing and abseiling – all put into a context following initial skills acquisition by an engineering metaphor. For example, undertaking a river gorge crossing, replicated by the establishment of and delivery from a production line for time/cost/quality. The evening programme recognised the formation of a team from a group of people brought together to achieve a task – "forming-storming-norming" (Tuckman, 1965), role adoption (Belbin, 2003), team-building skills (Lewis, 1995), and effective team building (Adair, 1986). The acquisition and development of skills in communications, delegation, meetings/negotiation, time management, resource allocation/use was through the use of role-play management games – for example, the delivery and installation of a new computer facility. The pedagogy in selecting these activities (daytime and evening) was to provide metaphors using outdoor pursuits and role-play activities that experientially offered learning opportunities with scope for subsequent debriefing according to Kolb's experiential learning cycle (Kolb,1984).

Student groups were pre-selected from across the Masters programmes, the groups were expected to self-cater and manage themselves in their groups whilst at the Centre, but were taken to and from the Centre by coach from Birmingham. Each student group was facilitated by a (volunteer) member of staff from the School, with the activities under the operational responsibility of the skilled Centre staff.

Lessons learnt

The original, 5-day 10 credit module established in 1989 was run back-to-back for two courses over 10 days in order to accommodate the number of students (60 plus each year, from 1989 through 1995). Two alternate versions of the course (5 day/postgraduate from Monday to Friday, and 3 day/undergraduate from Friday to Sunday) are now offered that have each taken onboard developments resulting from lessons learnt year-on-year. For example, the outdoor pursuits emphasis to achieve the task “at all costs” often took over from the process and could detract from the learning experience. Post-activity debriefings were introduced, using Kolb’s experiential learning cycle (Kolb,1984) to emphasise the need for reflection and transfer, and staff facilitators from Birmingham became team mentors to encourage this.

Changes in health and safety legislation from 1995 required the Centre to engage more staff who were professionally-qualified in the respective outdoor activities; this fitted well with the change in emphasis from challenge to competence. Support staff were also appointed at the Centre, so that students were now on fully-catered courses and benefited from some “down-time” and socialising on what had otherwise been full-on activity from 8.00am to 9.00pm.

This opened up the scope to introduce a day-long, team-oriented activity to conclude the course, and to move the assessment to an evaluation of the student’s development and attainment of competences over the duration of the course. The focus therefore could shift from solely “the team” to their own self awareness, awareness of others, self confidence, and self and peer appraisal toward the team’s development and performance. Examples of the day-long activity have included design/build of structures, modes of transport, feasibility studies for local amenities (hotel/marina complex), and the design/planning for a new educational adventure day. Teams are expected to engage in inter-team collaboration, use a diversity of management skills and demonstrate their engagement and contribution; mentors meet on a one-to-one basis with their team members to give formative feedback and on leaving the course, students are given a summative interview. Their team is assessed for its working over the week, demonstrably presenting their work without the aid of PowerPoint and undertaking peer-review of other teams. The role of the mentors cannot be over-emphasised, and has been informed by the Concerns-Based Adoption Model (CBAM), see (CBAM, 2008).

The 5-day course module continues to run, under the direction of the principal author for MRes, EngD and PhD students in Metallurgy and Materials from Birmingham and Imperial College; postgraduate students in engineering disciplines no longer take the module following further rationalisation of their postgraduate provision from 2002. [This is discussed further in the Conclusions to this paper.] The 3-day short course for undergraduate students in mechanical and manufacturing engineering degree programmes continues, with sponsorship from industry. This course is repeatedly run by the authors over several weekends to accommodate the 160 plus students in cohorts of typically 32 students per course.

Alternate models

From 1995, the School experimented with a number of alternate models, in addition to development of the content of the 5-day course. This has included running shorter courses at 2-day, weekend, and 4-day, and as longer courses of 7 days. Experiences from the shorter courses indicate that in the time available, students are unable to move along the continuum, from forming as a team from a group of people (with the need for adherence to ground rules, methodologies for working, strict adherence to roles etc), through storming (with intra-group conflict and emotions), to norming (with a constructive informality and synergy). Only the longer courses allowed teams to move comfortably to performing (with flexible roles and task performance), but it was exhausting for all (students and staff).

The authors have also run courses for groups from industry and commerce, where the teams have been previously-established, or are newly-formed that need "knocking into shape". These present their own challenges, as often attendees bring their prior baggage with them, and have several pre-conceived ideas of the team and others within it. These need to be put to one side before any progress can be made along the forming-storming-norming path.

The principal author has also had the opportunity to engage some of the learning styles from the courses at Coniston back to in-house modules from engineering; for example, in robot systems design (Steiner, 1997b), and in integrated manufacturing systems (Steiner, 1998). These courses provide an ideal opportunity to replicate the project team in industry, to undertake investigative and feasibility studies where the activities are far in excess of the work that can realistically be undertaken by one or two persons. These 10-credit modules have been one semester in duration (100 hours equivalent of student effort), where the student group has been responsible for the breakdown of the task into areas of activity, that they are then required to investigate and collectively present and report on.

The examples given so far all indicate good, formative teamskills development taking place in the context of the module, where the students are working together over the normally-perceived duration of the module. There are examples from elsewhere that demonstrate the importance of students engaging in teamskills development in a context from their discipline or industry sector; the case study from Coventry University (LTSN Engineering, 2004) is one example.

The School of Manufacturing and Mechanical Engineering has run group projects for many years, in particular its Product and Manufacturing Systems (PAMS) since 1989 and its Mechanical Engineering Integration Project (MEIP) since 1995 (Steiner et al., 1997a). These projects now span from Level 2 to Level 3, where the student teams engage in the Conceive, Design and Make phases of their chosen artefact across these two years of their programme of study.

The project groups attend a formative 3-day teamskills course at Coniston in the semester prior to commencing on their project; the benefit is that the students are already some way toward being a working team by the start of their project work, and this has enabled the duration of the project to be shortened by up to six months. The courses at Coniston are sponsored by Britvic Drinks, who also send teams of their own staff on the long-weekend courses with the student groups. From above, it is recognised that a 3-day course in itself is insufficient to facilitate the development of teamskills along the continuum identified by Tuckman of "forming-storming-norming" (Tuckman, 1965); more significantly, it is to recognise that the course is formative, that students are then given an experiential environment to practice and mature their skills development that is timely to the course, and that is appropriately supported by

their project tutor.

Student group working, and the encouragement of skills development, is well researched, and examples are available, for example through the search facility of the Engineering Subject Centre's website; examples to cite include the LTSN Engineering Mini-Project at the University of Sheffield (LTSN Engineering, 2003), and Student learning teams at University of British Columbia (Aman et al, 2007).

At the University of Sheffield, the LTSN-funded Mini-Project looked at the use of training exercises in group project working that included team skills, meeting skills and negotiation skills. The courses at Coniston are able to encompass and integrate these skills developments through the experiential activities available from a residential course at an outdoor pursuits centre.

Similarly, the research project at the University of British Columbia focussed on group learning, and through surveys of the student participation, were able to comment on supporting group function and minimising dysfunction through appropriate instructor support and role modelling. As mentioned, significant emphasis is placed on the role odf the mentor to the courses run at Coniston.

Students' reflections

At the end of the course at Coniston for postgraduates, the students complete a feedback questionnaire that is intended to inform the authors on a number of points: how the course ran, how it was received, how it was supported, and the value of the course in terms of the student's personal development. In addition, there are the "free-format" qualitative questions of "what did you like most/least about the course".

Some of the scores are influenced by the weather as it is always more enjoyable to be taking part in outdoor activities in sunshine rather than gale-force wind and rain. That apart, students mostly comment on the high standard of the activities, the materials and the facilities. They recognise the course as an opportunity to do new activities, the chance to work in a team in a neutral environment, and welcome the positive feedback and encouragement from Centre staff and mentors.

The degree of debriefing and feedback, however, is a key learning point – how much do you give and how frequently? In response to some student concerns, the post-activity debriefings have been scaled-down and more opportunity given with concise one to one meetings with team mentors during the course that allow more formative, individual feedback for the student's own self-reflection and development.

In general, the students would prefer no evening activities, but when challenged to suggest alternatives, then they had limited (and unrealistic) suggestions. The evening programme is now less intense, with fewer activities or classroom-based work; instead, more time is given to the students for working in their team from an earlier point in the course on the planning toward their last-day activity.

Finally, students have commented on the need, with the number of overseas postgraduate students on these courses, for staff to be considerate of the students' need to learn and work with a new vocabulary in team skills and on outdoor activities. This is an interesting dimension to bring into consideration, reflective of the real-world scenario of international/global teams where it can mistakenly be assumed that everyone speaks in a common language.

Learning points for the students

The learning outcomes of the course include heightened self awareness and awareness of others when working within a group or team, the development of self-confidence in role adoption, and abilities in self and peer appraisal. This is encouraged through a programme of challenging, demanding and enjoyable activities set in an outdoor pursuits environment. These outcomes are all qualitative, where students will be along a scalar of formative development that should be a continuum into their professional careers. Significant emphasis is therefore placed in the role of the mentor, to ensure in their one-to-one sessions with their team's students that they explore personal commitment and contribution to the team, exemplar high and low points from an activity/the day/the course, their perceived adoption and adaptation to team roles [as given by Belbin (2003) rather than Myers-Briggs (2008)], and to put activities from the course into a "work" context. The mentors are skilled in using open questions, encouraging self analysis by the student, and exploring their personal development and their perception of the team's formative dynamics. A record of the three one-to-one debriefings is maintained by the mentor, and given to the student on completion of the course, together with their overall summative assessment from the presentation of the final day's team challenge.

As indicated, the module for the postgraduate students is optional; students are perceptive to see the potential of this course in their professional development and therefore undertake the course with a high degree of commitment and consequent achievement. The feedback provided through the mentoring activity suitably informs the student of their attainment toward the learning outcomes of the course.

In conclusion

Many hundreds of students have taken the team skills and management development courses outlined here, and probably the most enlightening feedback from them is when we meet them several months later, as graduates and either in employment or seeking employment. Many cite their experiences in team skills and management development in applications and at interview with obvious enthusiasm and strong, favourable memories, often of skills put into practice elsewhere. This must be the best accolade to their learning experiences in team skills and management development.

The teamskills course at Coniston was removed from the postgraduate provision in engineering when it became modular in 2002, with declining numbers of students recruited to the reduced portfolio of postgraduate programmes in engineering at Birmingham and pressures on the available time in the students' curriculum. It is probably timely that those now responsible for the taught, and possibly research-led, postgraduate provision in engineering at Birmingham consider the re-introduction of the teamskills and management development module to their programmes. In particular, it would be beneficial to hold the course as a residential, getting-to-know-each-other experience early in their academic year, so that the students gain a year-long benefit for future collaborative working during their studies rather than immediately prior to their industrially-based project placement. This would have a cumulative effect, and would be of even greater benefit in the students' going forward to their project and onward into their careers as professional engineering managers.

The authors are pleased to note that the 3 day intensive version of the teamskills course remains in the programme of study for all mechanical and manufacturing engineering undergraduates, at the start of their second year of study and immediately prior to their MEIP and PAMS projects. Also, the 5 day, full version of the course is increasingly popular with the MRes/EngD and PhD students in

Metallurgy and Materials at Birmingham and from Imperial College, where it is an option module from their programme of study.

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