GLOBAL ENGINEERING CHALLENGE: A CURRICULUM INNOVATION TO INSPIRE RATHER THAN ASSESS

R.P. Horn*, P.B. Murray

University of Sheffield, Faculty of Engineering

Abstract: Recognising the need to inspire students and develop graduates equipped to meet the challenges of an increasingly globalised world, the University Of Sheffield Faculty Of Engineering developed an exciting new faculty-wide non-credit-bearing project and skills week for all 900 first year student engineers. Projects based on the Engineers Without Borders Challenge acted as a vehicle for developing broad professional, employability and academic skills within a global engineering context.

During the week, working in multi-disciplinary groups of 6, students were challenged to tackle real-world problems from a global perspective, thinking not only about the technical issues involved in solving problems and engineering creative solutions, but also the social, ethical and environmental considerations required for effective, sustainable solutions. Group project work was interspersed with interactive sessions on topics that progressed the project and / or developed generic skills. These were facilitated by postgraduate facilitators dedicated to hubs of 36 students (6 groups). The week culminated in presentation / competition for best project.

This paper describes the challenges involved in organising a non-credit-bearing project on this scale, across different departments and the co-ordination, development and training undertaken by staff, students and facilitators. Results and evaluation of surveys of student motivation and engagement in this project are also presented.

Keywords; inspiring, engineering education, global, employability, multi-disciplinary, group working

*Correspondence to: C.O. Rachel Horn, Department of Civil and Structural Engineering, University of Sheffield, Sir Frederick Mappin Building, Mappin Street, Sheffield, S1 3JD, United Kingdom. E-mail: R.Horn@sheffield.ac.uk

1. INTRODUCTION – A CURRICULUM INNOVATION

In a global, increasingly inter-connected world, where projects are complex, professionals from a wide range of disciplines work together, integrating knowledge and skills to achieve appropriate solutions. However, many student engineers have little opportunity to work with others outside the silo of their department speciality. While there are some good examples of integration between disciplines and departments, The University of Sheffield Faculty of Engineering recognised that there was potential for more collaboration to introduce experience of cross-faculty multi-disciplinary working into the curriculum. This led to a working group of staff members from each of the nine engineering departments looking at opportunities for developing a vehicle to facilitate wider integration and exposure of students to inter- and multi-disciplinary projects.
In this paper we discuss the compulsory, but non-credit-bearing project that was developed in response. The project, which became known as the Global Engineering Challenge (GEC) took place for the first time in January 2012 and involved 900 students from across the Faculty of Engineering. We outline the main drivers, aims, constraints and benefits as well as the challenges of developing and implementing a zero-credit project and what we have learned from running the week. We also present some initial findings from evaluations of the week, drawing on student opinions as well as staff and post-graduate facilitator impressions and feedback.

2. THE PROJECT IDEA

2.1 The drivers

Around the same time as the faculty were exploring opportunities for interdisciplinary projects, various other initiatives and strategies were leading to similar and complementary conclusions:

- The University Learning and Teaching Strategy (The University Of Sheffield, 2011) identifies both employability and internationalisation as key themes. For all students, development of skills and broadening awareness of global issues and impacts is important, however, with respect to internationalisation, there are two contrasting priorities:
  - For home students, the global marketplace and the fact that many future graduate careers are likely to involve an international dimension, means that it is important for students to develop cultural agility and broaden awareness of international issues.
  - For international students (one third of engineering students), for whom development of cultural agility is already an on-going process, the main focus is on facilitating this transition, and improving integration with home students, particularly in group project work, overcoming barriers of language, culture and teaching and learning styles.

- Recent institutional body focus on global development has led to publication of a number of reports that aim to influence the actions of professional engineers as well as the focus of engineering education including Bourn and Neal (2008), The Royal Academy of Engineering (2005, 2008, 2011).

- The recent 3-year project "A Global Dimension for Engineering Education" (The Higher Education Academy, Engineering Subject Centre, 2010) aimed to encourage embedding of global knowledge and awareness into the curriculum: the challenges of sustainable development and the importance of integrating technical knowledge within the wider context of social, environmental and economic development.

- Some faculty staff and the careers service had developed engineering-focused workshops on job applications and interviews aimed mainly at final year students. These sessions revealed that students found it difficult to articulate and provide evidence of their own skills and to recognise how these matched attributes required by employers. It was also clear that most students left consideration of employability and career planning until the start of their final year, when they started to look for graduate jobs. By this time there is little scope for engaging in extra-curricular activities to address gaps in their skills portfolio.

2.2 Initiation and Aims

The GEC project week was conceived in February 2011, when discussion about the need to develop and improve global and employability skills coincided with a decision to move towards
20-credit year-long modules in all departments across the Faculty of Engineering. This change, which resulted from discussions on the effect on learning of modularisation and bi-annual examinations, freed two weeks of the January examination period. This created mutual space in the timetable to run a cross-faculty multi-disciplinary project.

Having decided on a week-long project with the overall aims of developing (and recognising) global and employability skills, a project group met to discuss and identify the specific skill-development aims and logistical constraints. The project group was comprised of departmental representatives as well as other faculty, careers service and learning and teaching staff.

2.3 Constraints and obstacles
The obstacles to be overcome in developing the project week were principally associated with the size and nature of the project:
- Size, space, IT requirements and management: for approximately 900 students
- Project basis – requirement to be accessible and interesting to students from all departments.
- Credit and assessment requirements
- Staff workload: this was to be an additional project in the curriculum requiring development and delivery – there was a desire to minimise impact on staff workloads
- Co-ordination: agreement required from nine departments of the Faculty of Engineering

2.4 Project requirements and outline
The inter-linked problems of size, assessment and staff workload led to a decision to make the project non-credit-bearing. This reduced the impact on staff workload and removed the problem of consistency in marking. However, this also meant that we had removed a common motivator of student engagement and performance. Therefore we needed the week to inspire. Engaging 900 students to work in multi-disciplinary, multi-national groups over the course of a week would rely on interesting, interactive and fun activities, a stimulating project basis, as well as an appropriate organisational structure. By interspersing facilitated, interactive taught sessions with group project work throughout the week, we hoped to balance structured workshop time with independent group work and freedom to research and develop their own ideas. By introducing the end product of a group presentation with prizes, we hoped to promote group competitiveness. Winners would be decided largely by the students, and it was hoped that both peer-assessment and competitiveness would help to nurture engagement and motivation.

We needed to identify a project that would integrate the key skill development aims and be accessible to all students, from diverse backgrounds and with little discipline-specific expertise. At this time, Engineers Without Borders UK (EWB-UK) was developing the EWB Challenge for UK universities (Engineers Without Borders UK, 2011). This is based on the EWB-Australia Challenge that reaches approximately 8000 Australasian university students each year. In most cases, the EWB challenge is embedded into the curriculum: as part of a module, students work in teams to research and develop sustainable solutions to real problems faced by a community in a developing country. The potential projects, which are organised into themes (such as water and sanitation, energy, waste), are diverse, open-ended, applicable to a wide range of engineering (and non-engineering) disciplines and adaptable to different formats and levels of detail. The UK version of the EWB challenge was considered an ideal basis for the project:
the projects and context had already been developed (though scope would require adapting for the constrained week-long duration);  
the central theme of sustainable development and consideration and understanding of global issues reflected our aims for the week
EWB-Sheffield branch has a high profile and is of interest to a range of students, so would contribute to motivation.

For the week, students would be organised into mixed groups of approximately 6 students (mixed departments and home / international), and facilitated sessions would be delivered to hubs of 6 groups (approximately 36 students). Thus, we would require 25 rooms of appropriate size and IT facilities and suitable for interactive group work. Each hub room would require a facilitator to lead the “taught” sessions.

We decided to employ postgraduate facilitators to deliver the project. These facilitators would be selected for their ability to facilitate discussion and would be trained in facilitation and small group teaching. As well as mitigating impact on staff workload, this would have the benefit of providing teaching / facilitation training and experience to a large number of postgraduates. These facilitators would deliver “taught” content, advise and help groups to progress solutions, and help to address internal team working problems. Staff input was limited to group project time, when they too would provide advice on progress and help to address team working issues.

Whilst two members of staff would be responsible for developing / co-ordinating development of most of the project materials for the taught sessions, the faculty project group of departmental representatives would continue to meet at intervals for updates on the general direction, content and structure of the project.

3. DEVELOPING THE GEC PROJECT WEEK TO INSPIRE AND MOTIVATE

3.1 Overview of week and session format
The GEC week was designed as a series of taught interactive workshops / discussions (rather than lectures) interspersed with independent group project working time. Taught sessions focused on topics that would help students to tackle and progress their project and final output (a peer-assessed presentation). Table 1 shows an overview of the “taught sessions in the week.

3.2 Developing and testing materials
In order to make the interactive sessions as interesting and engaging as possible, three undergraduate students were employed during the summer vacation to help research ideas and information and to help develop the sessions, providing a student perspective on the sessions. An iterative process of development and testing the materials was also undertaken:

- Research and initial session development (undergraduates and staff)
  Test materials on small groups of students. Sessions were delivered by the member of staff, with undergraduate developers observing. Feedback discussion with participants after each session indicated what was interesting / boring / confusing etc. This showed that the experienced member of staff would naturally adapt / improvise to achieve good interaction / explanation, which may be difficult for inexperienced facilitators delivering the material.
- Major materials development by the member of staff in the light of earlier stages.
Re-testing of some materials on a small group. A postgraduate facilitator was employed to deliver the session, with the member of staff observing, and feedback from the participants.

This sequence of development and testing was a valuable experience, providing direct feedback on what was effective and what could be misinterpreted, or had been pitched at the wrong level. General comments showed that students were enthusiastic, and contributed well to discussion, although several expressed concern about student attitude if the week was non-credit bearing.

<table>
<thead>
<tr>
<th>Session title / format</th>
<th>Aim to develop and inspire…</th>
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<tbody>
<tr>
<td>Plenary introduction</td>
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<td>• Faculty Pro Vice Chancellor</td>
<td>Introduction &amp; context of global workplace</td>
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<tr>
<td>• “Clicker” session (electronic voting system (EVS)) on global awareness</td>
<td>Stimulate interest and raise awareness of global issues</td>
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<tr>
<td>• Employer representatives of international engineering companies</td>
<td>Awareness of employer view of grad. skills and importance of global issues in industry</td>
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<tr>
<td>• EWB Challenge &amp; GEC presentation</td>
<td>Intro and overview of the aims of the week</td>
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<td>Team working workshop – team-based active exercises interspersed with presentation and discussion points</td>
<td>Active team building and introduction</td>
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<td>• Appreciation of diversity (cultural/discipline)</td>
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<td>• Team communication</td>
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<td>• Professional attitude to teamwork</td>
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<td>• Task and group management skills</td>
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<td>Sustainable development – variety of active exercises, presentation and discussion points</td>
<td>Awareness of global issues (social, economic, environmental, resources, systems approach)</td>
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<td>Problem-solving – video, presentation and series of short, interactive exercises</td>
<td>Process for tackling problems and identifying and developing solutions</td>
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<td>Professional responsibility and ethics – presentation, discussion points, clickers &amp; video</td>
<td>Professional and ethical responsibilities of engineers, appreciation of ethical dilemmas and relevance at university incl. plagiarism</td>
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<tr>
<td>Effective communication – interactive exercises, video, discussion and clicker session</td>
<td>Communication with impact, methods available, skills, addressing fears of presenting.</td>
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<td>Employability skills audit – recent alumni visit and talk about their experiences and skills required in industry</td>
<td>Awareness of skills already developed</td>
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<td>Inject enthusiasm and authority / reality w.r.t. employability skills</td>
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<td>Peer review and using feedback – video and discussion followed by active peer review and feedback on draft presentations (teams paired)</td>
<td>Critical assessment of others’ work w.r.t. assessment criteria, giving feedback and using feedback to improve</td>
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<tr>
<td>Reflection and skills / career planning – discussion, self-reflection and planning</td>
<td>Use previous skills audit to identify gaps and plan to develop</td>
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<tr>
<td>Final presentations – assessed using clickers (peers, staff and facilitators)</td>
<td>Communication skills and critical assessment of others’ work</td>
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<tr>
<td>Plenary finale – video of the week’s activities (The University of Sheffield, 2012), clicker evaluation</td>
<td>Conclusion, evaluation and prize giving</td>
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Table 1 Overview of taught sessions, interactive format and session aims
3.3 Selecting, training and managing facilitators
While content and structure of the sessions contributes to the level of interest and student engagement, the key factor to inspiring and motivating students is how the sessions are delivered. This meant that it was important to select the best facilitators and provide training in small group teaching and facilitation.

An application and interview process was developed to select postgraduate students who would be best able to engage, manage and motivate students during the week. Group interviews were undertaken, with candidates asked to give a short talk on an aspect of sustainability, to facilitate a short discussion with other interviewees on a slide produced as for one of the sessions, and to answer questions on group management. This interview process also provided useful feedback on how different people interpret the session materials, which again led to some re-development.

After selection, facilitators undertook training in small group teaching and seminar facilitation, provided as part of the Sheffield Teaching Assistant training (Sheffield 2011b). The member of staff running this course commented on the high standard of postgraduates on this session, highlighting the value of the selection process. Further targeted training was provided on the GEC materials and on using technology such as the electronic voting system.

During the GEC week, we held daily feedback and briefing sessions for the facilitators. This provided a useful forum for feedback, discussion, sharing of best practice and communal problem solving. It also provided an invaluable opportunity for staff, who were co-ordinating the week, but distant from the hubs to monitor progress and levels of engagement.

4. EVALUATION

4.1 Evaluation and feedback
Before, during and after the week, first year students were surveyed to establish their attitudes and opinion of the project. These surveys took different forms:

- Before the week an online MCQ quiz (via the VLE) to self-rate skills abilities and to gain opinions on the importance of learning about global issues and developing employability.
- An e-voting system for the same MCQs in the closing plenary lecture at the end of the week.
- Three weeks after the GEC week, an online questionnaire asking their opinions of the week. This provided quantitative and qualitative feedback.

Additional, anecdotal evidence is available from personal conversations and emails. In addition to these student surveys, we also collected opinions and feedback from facilitators (via an online questionnaire and open verbal feedback discussion) and staff through verbal discussion sessions.

4.2 Results and discussion
The MCQ quiz in the VLE was answered by 686 students at the start of the week and by over 316 students in the closing plenary using the e-voting system. All responses to questions about the importance of learning about global issues and developing employability skills showed an overall improvement in opinion although in each case there was also a small, but consistent negative shift towards the most negative answer (Horn et al., 2012). We have not been able to investigate this result further, but it is thought that this could result from student behaviour in a lecture theatre amongst their peers.
170 students (19% of the total) completed the online questionnaire 3 weeks after the project week. The results of one question that related directly to student motivation in the week, and therefore whether we have achieved our aim of inspiring the students is shown in Figure 1.

![Figure 1 Student motivations during Global Engineering Challenge Week](image)

Figure 1 shows that the most popular of the choices provided was becoming a better engineer, which was chosen by 90 of the 170 students. Employability and helping the people of Devikulam (the community focus of the EWB project) were also ranked highly, however 47 of the 170 students who responded to this survey (28%) indicated that they were not motivated. While this is disappointing, it may be partially attributed to negativity bias, particularly in view of the relatively low response rate to this voluntary survey.

During the week, we were aware of a small proportion of students who did not engage / lacked motivation and made it difficult for team members. One commonly vocalised dislike was “9 to 5 working”. However, verbal feedback during the week from students, staff and facilitators was overwhelmingly positive – enthusiasm increased as the project progressed and groups started performing. Good attendance at the closing plenary (4pm Friday) was also a positive indicator.

Free-text responses to the question on motivation showed two other frequently-mentioned factors: working with a good team/team member and the hub facilitator. Another free-text question in this questionnaire asked “What was the best thing in the week?” This question received 67 responses, of which the single most popular thing cited by students (about 50%) was teamworking and meeting new students. These responses were often refined to recognise the value of diversity in the groups. The following comments exemplify the responses:

- “meeting new people from other departments and working around our differences”
- “Getting to work in a multicultural team”

The second “best thing” that emerged was the real life nature of the projects with 12% of respondees citing this.

These findings of the motivational effect of teamworking and realistic projects and the hub facilitator are corroborated by anecdotal evidence, with both staff and facilitators reporting good engagement within the teams, enthusiasm for the project work and high quality final presentations. Students also rated group working most highly of all of the week’s sessions in a question relating to their development as a student and graduate engineer (Horn et al. 2012).
5. CONCLUSIONS – WHAT WE HAVE LEARNED

Overall the project week went very well. Staff and facilitators were impressed by student engagement and the quality of project work, and the majority of students were interested and motivated. Particular highlights were the use of independent group-working, the realistic project basis and the enthusiasm and motivation provided by the post-graduate facilitators. Facilitator training played a key part in this.

We have learned a great deal from the experience of running the project, as well as from the student feedback. Many of the learning points relate to the issues that are key to managing a project on this scale: time involved in planning, logistics, communication and organisation (as well as time for session development and testing). We will be developing handbooks for students and facilitators, and improving communication with all those involved. We are continuing to evaluate feedback and will use this to adapt the facilitated sessions – the Global Engineering Challenge will now become a regular event for first year students.

6. REFERENCES


The University Of Sheffield, 2011b. Sheffield Teaching Assistant. Url: http://www.shef.ac.uk/lets/sta (04/04/10)