

# Global Engineering – a design and build challenge

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## Abstract

*Engineering is a global industry undergoing a period of unprecedented change.* This statement was highlighted within the Global Engineer report, commissioned in 2008 by Engineers Against Poverty. The report highlights that the future of engineering is being framed by global forces which transcend national boundaries, including climate change, water scarcity and inequality. Therefore to tackle these global forces, engineering education must adapt to provide this dimension in an undergraduate's education. Currently this element is missing entirely, focussed on sustainability only and where present is often poorly delivered within Higher Education institutions.

At Newcastle University, the School of Civil Engineering and Geosciences (CEGs) has developed a theme within the undergraduate degree programmes focussed on these global engineering challenges incorporating ethics, sustainability and human demands and impacts. The higher level of this theme is to complete a design and build challenge in a developing country.

This paper presents a case study detailing the development of this theme within the undergraduate programmes in CEGs, culminating in the design and build challenge module. This challenge was a real engineering problem, defined in partnership with Raleigh International, to provide a cleaner, safer and more secure water supply to a rural community in a developing country. To achieve this challenge, the students spent semester 1 designing solutions to the problem brief. In semester 2, the students spent three weeks in-country implementing the chosen engineering solution as a team of engineers. The students implemented a water system within a rural community in the Pitass region of Sabah in Borneo. Whilst doing so the participants were living and working in remote and very basic conditions, and were expected to manage the project within the expedition timeframe and also had the opportunity to meet engineering peers from the University of Malaysia and local engineering firms.

Along with the clear benefits to theory-based and 'hands on' engineering, the expedition model also provided the opportunity for the students to develop their leadership, communication, team working and professional skills.

## **1. Introduction**

External drivers urging the Higher Education sector to readdress the educational requirements of a modern civil engineer have been gaining momentum over the last decade. In the opening address of the Royal Academy of Engineering Working Group launch, Professor Julia King as the Chair of this group said *'Amongst the greatest challenges we face in the world today are those of delivering growing, secure and affordable supplies of clean water and of energy, to meet the needs and expectations of an expanding population, whilst reducing our CO<sub>2</sub> emissions and the human contribution to climate change. The implementation of innovative engineering solutions is fundamental to addressing these challenges'* (Educating Engineers for the 21st Century, 2007). In 2008, the Global Engineer report, commissioned by the Department for International Development, urged Higher Education Institutions engaged with engineering education to undertake a review of existing courses in the light of the global dimension. As a pacemaker of civil engineering education in the UK, the School of Civil Engineering and Geosciences at Newcastle University, UK, conducted a root and branch review of their civil engineering undergraduate programme provision in 2008. The vision for this programme was to address the major civil engineering challenges of the 21st century facing a graduate engineer through a multi-disciplinary holistic approach. This multidisciplinary approach would also recognise the importance of the societal challenges within a civil engineering context. The new undergraduate structure was based on 5 thematic threads, namely Infrastructure Systems, Environmental Systems, Modelling and Information Systems, Design of Sustainable Engineering Systems and Human and Management Systems (Glendinning *et al.*, 2013). These themes are not rooted in the traditional disciplines of Structures, Geotechnics, Hydraulics, etc. but cross-cut these traditional disciplines into focussing development of an integrated holistic solution whilst maintaining all elements of the academic knowledge and content expected within an accredited programme.

## **2. Structure of the undergraduate degree**

The need to adapt and refine a curriculum to keep pace and anticipate the global market place for engineering graduates is widely recognised by government, business, engineering institutions, accreditation bodies and the university themselves (Global Engineer, 2008). In 2012, the Institute of Civil Engineers redefined its strategy and vision for the next generation of engineers as one which must embrace a changing multinational focus situated in consolidating global industries. The thematic structure of the undergraduate civil engineering programme at Newcastle does just this and is presented in Figure 1. This integrated programme approach has sustainable development at its heart, engaging with the environmental, social and economic dimensions of this unifying concept in the design, implementation, and rehabilitation of all civil engineering interventions within the Earth system. It challenges students to think not only about the technically demanding subjects but also about the future challenges of climate change, sustainable development, democracy, equity, poverty alleviation, and the lifelines of energy, food and water. Further discussion of the evolution of this programme is found in Glendinning *et al.* (2013) and Hall *et al.* (2013).



Figure 1: Thematic structure of the undergraduate civil engineering programme at Newcastle

This paper will focus of the staged development of the Human and Management Systems (HMS) theme and how present a case study solution to incorporate these issues into an interactive Design and Build Challenge module in the fourth year of the MEng civil engineering programme.

### 3. The Human and Management Systems theme

The aim of the HMS theme is to understand the economic, social and behavioural functions and interactions between humans and the infrastructure systems that civil engineers provide in a global context. This theme also develops advanced abilities in planning, management and economics, in order to train the graduate to lead projects as a professional engineer.

Each year of the programme has a set of specific objectives to address through the modules delivered within this theme to fulfil prior learning for the next year. These objectives are presented in Table 1.

Table 1: Objectives and modules within the HMS theme

Year	Objective	Compulsory or Optional	Module title	Credit Weighting
1	Introduce the societal context of civil engineering, at present, in the past and in the future. Provide a broad and clear set of challenges that Civil Engineers must meet in their professional capacity	Compulsory for all civil engineering students	Human Systems Demands and Impacts	10
2	Understand the construction process, project lifecycle and safety. Develop the ability to model, simulate and assess the interactions between humans and the built environment.	Compulsory for all civil engineering students	Land, Highways and Transport Planning	10
3	Master methodologies for the financial and economic appraisal of civil engineering projects, their procurement and management	Compulsory for all civil engineering students	Construction Management	10

			Engineering Ethics and Sustainability	10
4	Develop mature understanding of the roles and responsibilities of civil engineers in a global framework.	Compulsory for all MEng civil engineering students	Construction Project Management	20
			Public Policy and Sustainability	10
		Optional – all MEng students must take ONE of these modules	Enterprise for Construction	20
			Career Development for Masters level students	20
			Global Engineering – a Design and Build Challenge	20

With the assumption that by the end of the third year, the students have a solid foundation of knowledge regarding the interaction of civil engineering and the associated societal impacts, the fourth year of the degree programme primarily focusses on the application of this knowledge to largely unseen situations. It is this part of the programme that builds upon on the first three years of the civil engineering programme and enhances the development of competence in the areas of global engineering and sustainability literacy which are requirements of a graduate (Cotton, 2010).

#### 4. Global Engineering - a design and build challenge

This module was introduced in the 2012-13 academic year, as one of three optional modules that an MEng civil engineering student may elect in their fourth year. All three of the optional modules focus on broadening a student’s perspective of the workplace and developing skill attributes in line with the Graduate Skills Framework Directive. This module combines the focus on graduate skills with a unique opportunity to experience hands-on engineering in a developing country.

The aim of the Global Engineering module is to design and build an infrastructure project overseas whilst also developing teamwork, leadership and reflective reporting skills. This module challenges students to apply their engineering skills, knowledge and teamwork within an unfamiliar environment. Of equal importance to the design and construction is the leadership, teamwork and communication skills the students develop whilst interacting with professional engineers and local communities overseas. The module challenges their ability to self-manage, proactively interact with a variety of people and their resilience to leadership within a challenging environment.

The module is led by Newcastle University who are working in collaboration with Raleigh International. Raleigh International is a youth (people under 25 years old) and sustainable development charity with over 25 years' experience of providing expeditions in challenging environments. Raleigh's overarching aim is one of uniting people as part of a global community and providing a transformational journey for everyone who joins. This unique collaborative arrangement allows the module to be implemented within a long-term sustainable vision of the host country and associated NGOs. Raleigh International provide the detailed project constraints alongside the infrastructure and logistical support whilst in the host country.

## **5. Module structure**

This module is a year-long module and forms a sixth of the final year of the MEng degree programme. It is structured to provide the students with a real-life civil engineering problem facing a community in a developing country. The emphasis of the module is on holistic understanding of the in-country problem and the practical engineering skills needed to appraise the project site, formulate an engineering solution to the identified problem, and implement the project, all within a very tight timeframe of three weeks (including travel, induction and debriefing).

Semester 1 focusses on the individual fundraising element of the project and the production of a group design report. The students who elect to do this module are all challenged at the start of the project to fundraise £2300 each in order to participate and to fund the in-country project phase. This fundraising challenge is unique within the civil engineering programme but it serves to galvanise the students into a coherent team, develop their organisation, communication and personal enterprise skills. It challenges their usual methodology to a task and begins the structured critical reflective process which is further developed in later stages of the module. In addition to fundraising, the students complete an initial Graduate Skills audit and, working in small teams (approx. 5 people) they produce a short conceptual engineering design report.

Semester 2 is the expedition phase of the module where the students depart the UK and head to a developing country to complete an engineering task. In 2012-13, the project implemented was the installation of two gravity-fed water systems in a community within the Pitas region of Borneo. The students had to quickly adapt to:

- the project management challenge in-country with limited resources and time
- environmental stresses of the region with regard to temperature and humidity
- the cultural sensitivities of the communities with specific regard to language and cultural habits
- lack of 'home-comforts' as living conditions were both cramped and very basic and with no mobile communications or electricity available in the community

Whilst in-country, the students were observed and assessed by the staff on the project (both Raleigh International and Newcastle University staff) against criteria synoptic of the graduate skills development expected. The skill categories assessed were professionalism; initiative; team working; leadership; positive and realistic expectation; and communication. The students were all assigned a day of the project in which to lead, were asked to keep a log book to enable critical reflective learning to be utilised, and received one to one staff feedback in-country on their performance to date.

After returning to the UK, the students were required to make a presentation or produce a press article, complete a Reflective Report (supported by evidence in their log books), and attend an assessed interview based around their skills development, contributions and challenges during the module.

## **6. Module outputs and skills development**

As discussed in section 5, the module had equal weighting of both the technical demands of design and implementation in the field of a working system with the real personal development that a module such as this enforces. The technical outputs, namely a design report and implementation of a working system in-country, are relatively simple to assess with right and wrong solutions possible. It is much harder to assess success in transferable skills development (Hall *et al.*, 2013). The development of transferable skills is difficult to monitor, though the initial skills audit provided a starting point for most of the students. They identified a set of personal objectives to challenge themselves against which they would report, with tangible examples and evidence, at the end of the module.

In their reflective reports and assessed interviews, communication was a skill that most of the students identified as having improved, and several students referred to having set themselves objectives to improve on specific aspects of communication. The evidence of improvement was evidenced in terms of improved module marks for presentations as the year progressed, success at corporate communication for fundraising or just the added awareness of communication in both verbal and non verbal ways with a community who spoke little or no English.

Aside from the difficult climate and living conditions, many of the students identified aspects of teamwork and leadership as their greatest challenge during the module. The in-country experience of leading the team for a day was the subject of much personal reflection, and particularly appreciated by those students that were less confident in their leadership abilities. Increased confidence in both technical engineering ability and core graduate skills such as communication, team working and personal enterprise, were regularly attributed to the module.

## **7. Wider impacts of the module**

In their reflective reports and assessed interviews, the majority of the students referred to the unique experience of using their engineering skills in a global context to help people less fortunate than themselves, and some even alluded to a 'life-changing' experience. As a direct result of this, students have been proactive in writing publicity for the event resulting in some 10+ articles being published in the national and regional press. The alumni are keen to remain involved in the module to ensure its longevity within the university framework whilst giving the students the benefit of recent graduates' experience. Many of the graduates have found employment in multidisciplinary global consultancies, and have cited the module as playing a key role in providing them with real life examples to interview questions. While the module has received excellent overall student feedback in its first year, the work of evaluating detailed feedback and further improving the module is ongoing.

## **8. Conclusion**

This paper has shown that although the world is shaped by many global engineering challenges which transcend national boundaries, it is possible to embed this big-picture philosophy and considerations within a civil engineering programme. The opportunity to organise and execute a residential experience to address one of these key challenges first hand using engineering knowledge, has been proved possible. The assessment methodology used is designed to reflect the journey that a graduate civil engineer would experience on route to chartership. The module enhances many of the personal development skills expected by the Graduate Skills Framework, through the expedition day-leader roles, on-going reflective sessions, and the ability to communicate to a wide variety of audiences in different formats, whilst maintaining a positive, realistic and professional outlook as expected from a young engineer.

## References

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