Multi-disciplinary and cross year mentoring: the development of an eco-house and a sustainable marriage!

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***Abstract**: The paper initially describes the development of two interdisciplinary projects/ coursework, with the aim of achieving project goals through the use of inter-disciplinary/ multidisciplinary teams. The first, a one-fifth scale eco-house was designed and developed by a multi-disciplinary, cross-year group of engineering students in order for them to apply their engineering knowledge to analyse the efficiency and effectiveness of renewable energy systems. The second involved a group of postgraduate engineering students working with first and second year fashion students to examine the concept of 'throwaway fashion'. This concept enabled students to investigate dissolvable polymeric materials that could be used as fabrics to design a biodegradable wedding gown. The end product was a wedding dress that has been used in exhibitions across the UK.*

It then examines results from two internally funded research projects aimed at investigating and enhancing students learning experience through the formation of interdisciplinary links between design/ mechanical engineering final year project students and taught classes in other disciplines.

The paper then describes a Royal Academy of Engineering (RAE) funded "Large Scale Curriculum innovation and Enhancement project" between a collaboration of 6 UK universities with the aims of developing an interdisciplinary learning environment which can ultimately provide a model for embedding such enhancements across a wide range of universities.

Introduction

There has been an increasing requirement for engineers to be able to work across multi-disciplinary teams. In the UK as far back as 1988, the Integrated Engineering Degree Programme (Engineering Council, 1988) was launched as a national initiative to produce engineers with the knowledge, skills and qualities to be able to work across disciplines. This course was used as a vehicle to embed multi-disciplinary skills across engineering programme (Robinson et al, 1991, Harris et al, 1994).The growing trend is to develop engineers that can work outside their own discipline and to be able to lead and work within multi-disciplinary teams. The UK Standard for Professional Engineering Competence (UKSpec) (2004) states that "Chartered Engineers are characterised by their ability to develop appropriate solutions to engineering problems, using new or existing technologies, through innovation, creativity and change". It also requires that they "Engage in the creative and innovative development of engineering technology and continuous improvement systems. This could include an ability to establish users' needs and assess marketing needs and contribute to marketing strategies." It goes on to say that they can evidence this by leading and managing complex projects that involve market research, product and process research, and involving cross-disciplinary working.
In the USA, the Accreditation Board for Engineering and Technology (ABET, 2011) has relevant outcomes similarly to UKSpec:

- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multidisciplinary teams

Engineers Australia (2011) has accreditation requirements for a chartered engineer to have effective team membership and team leadership with an ability to:
- Understand the fundamentals of team dynamics and leadership.
- Function as an effective member or leader of diverse engineering teams, including those with multilevel, multi-disciplinary and multi-cultural dimensions.

The CDIO (Conceiving - Designing - Implementing – Operating) initiative, launched in Sweden (Berggren , 2003) aims to improve undergraduate engineering education in Sweden, the USA and worldwide. The goals are to educate students to:
• Master a deep working knowledge of technical fundamentals
• Lead in the creation and operation of new products and systems.
• Understand the importance and strategic value of their future research work.

CDIO provides students with an education that stresses engineering fundamentals set in the context of real-world systems and products. One of its themes is to ensure that students have opportunities to develop the knowledge, skills and attitudes to conceive and design complex systems and products.

It is therefore clear, globally, that multi-disciplinary project working is a key part of what is expected of a professional engineer. We therefore need to ensure that these skills and competences are built into our undergraduate and postgraduate engineering programmes. The following sections detail some of the developments and enhancements that we have undertaken within our university, together with details of a national Royal Academy of Engineering (RAE) Science Technology, Engineering and Mathematics (STEM) project (HE STEM, 2011) to develop curriculum to incorporate multi-disciplinary cross year working within engineering.

Initial Multi-Disciplinary Projects

1) A Sustainable Marriage

The project aimed to use the skills and knowledge of engineers working with fashion design students to re-examine the notion of ‘throwaway fashion’, promoting a new concept in clothing using dissolvable fabric, as a metaphor and as a vehicle – the resulting garment being able to dissolve into five new fashion pieces.

Several masters students studying a module entitled 'International product Development' worked with first and second year fashion design students. Initially fashion students took part voluntarily, but in the future it is proposed to be within a module- 'Fashion Interaction and Meaning'. By bringing together the skills of the Engineering students, working with Polymers and other biodegradable/ bio compostable materials and the Fashion students, who had skills of design, pattern cutting and garment manufacture, the aim was to produce the ‘Ultimate Wedding Gown’. The student cohorts worked together exploring innovations in materials, processing, industrial collaboration, the limitations/potential of the polymer fabrics, experimenting with the creative potential of the polymers through entrapment, vacuum forming, laser cutting and surface decoration.

The outcome of the project was the production and exhibition of the original haute couture wedding gown and several copies of the gown demonstrating its evolution as parts of it dissolve and become other garments or something else entirely, see Figure 1. The gown is intended as an allegorical piece but with a realistic commercial application.

Figure 1 The dissolvable wedding dress showing the varying stages of its dissolution

Benefits: The students/staff and university benefited from this experience in a number of ways:

- Sharing/building skills/knowledge of different subjects by looking outside primary subject area
- Benefit to retention as students are more motivated
- An aid to recruitment by creating the ultimate eco-dress, shown at open days
- Establishing collaborative links with industry, thus increasing students' employability, with possible enterprise spin-offs to generate income
- Liaising/working with people from different professional backgrounds/levels leading to enhanced communication skills
- Working as part of an small inter-disciplinary, enthusiastic team being challenged and inspired, building confidence and esteem

Evaluation

Students were interviewed through a focus group in order to qualitatively evaluate the outcome of the project. In addition, students were asked to reflect on their experience as part of the assignment. Several student comments are shown below.

"Sustainability project was a brilliant idea".

"…project collaboration with the fashion students is well worth the time inputted….helped in finding a market for our product…"

"I think the fashion group expected more from us…"

"The period allocated for this collaboration needs to be looked into for any future association…"

It was clear from the feedback that the students enjoyed the project and that inter-disciplinary team working benefited both groups of students, and that they believed that it would help with their future employability. The main criticism from students was a lack of time to undertake the collaboration. The project ran for only a few weeks of the semester, whereas ideally it would be better to run through the whole of one semester. The end of module questionnaire resulted in 85% of students satisfied or very satisfied with the module. Additionally, 95% of those that responded agreed to the question - "I can see how my learning from this module will help my practice".

2) Eco-house–the design and development of a scale-model, environmentally-friendly house.

A team of engineering students designed, developed and built a $1/5^{th}$ scale eco-house. The activity was part of a project to develop a teaching and learning environment for the development of sustainable literacy among students at the university. The project integrated into the students' final year project work and coursework assignments at a number of levels, as a context for applying engineering knowledge to analyse the efficiency and effectiveness of renewable energy systems. The students were

from mechanics, electronics, design, and architecture – bringing diverse skills into a multi-disciplinary team.

The eco-house was also used for school visits, university open-days, and learning and teaching seminars and conferences, to highlight the role of engineers in working towards sustainable development. The primary sponsor for the project was the Higher education Academy's (HEA) Engineering Subject Centre, with industrial, commercial and charitable trust sponsors providing further resources. The goal was to develop a working scale model of an eco-house capable of providing adequate levels of heat, power, light, and ventilation for the UK environment, maximising the use of local and natural resources, and minimising carbon impact and reliance on fossil fuels. A range of power generation systems (wind turbine, photovoltaic cells, integration with the national grid) and heat transfer systems (solar water heater, under-floor heating, air-to-air heat pump, passive solar heating and natural ventilation) and insulation systems (green roof, recycled fibre wall insulation, recycled glass and non-solvent based resin thermal mass, double glazing) were designed and built by the students .

The various systems were linked to an integrated electronic control system, which utilised the available energy from the various systems in response to the external environment to maintain internal comfort levels, and recording data to monitor performance. The eco-house is installed outside at the Sheffield Hallam University City Campus, where it is gathering performance data.

Figure 2 The one-fifth scale eco-house

In addition to the support of the HEA, commercial companies provided equipment and consultancy in return for being able to use the project to generate publicity for their company. The total value of the materials and time for the project was estimated to be £18,000, although it was achieved within a budget of £4,000.

Embedding the Eco-house into the Curriculum

The project was run by a working party of 8 final year students from mechanical, electrical, building services, and architecture, who each took responsibility for a key system of the eco-house. In addition several MSc students on a module entitled ' International product Development', undertook project work on the house as part of the modules 'group project'. Through the eco-house project the multi-disciplinary team have achieved a wide range of learning outcomes related to sustainability literacy. They were motivated by the ownership of an important aspect of the eco-house, and the ambitious scale of the overall project. The working party members responsibilities were the selection, development, sponsorship, building, integration, and testing of their system. The group identified aspects of the system which they were confident about, and aspects which would require either further research, or external support. The members of the working party were given the opportunity to gain the support of other student groups. They selected a challenging aspect of their key system according to the level of the student groups, collaborating with the teachers to developed assignments focused on their expertise. Once the assignment had been assessed, the working party members then selected the solution which was best for the eco-house, and incorporated it into the final design. The consultation process, competition, and the reward of influencing the project was successful in motivating the

students at undergraduate and postgraduate levels, and also developed interest in the eco-house project for the following year, and increased the circulation of sustainability literacy education via the eco-house context to a wide range of students.

3) Internally Funded Research Projects on Interdisciplinary Working

Following on from the projects already described, the Department of Engineering & Mathematics have undertaken other inter-disciplinary cross year projects with its students. A small teaching enhancement grant funded '*Expert mentoring in the development of teaching on a new Aerospace Technology degree'*. This involved 1st and final year students in the design and make of a gliding simulator involving expert mentoring / video conferencing between groups of students, within a formal classroom situation and an expert based in Sweden.

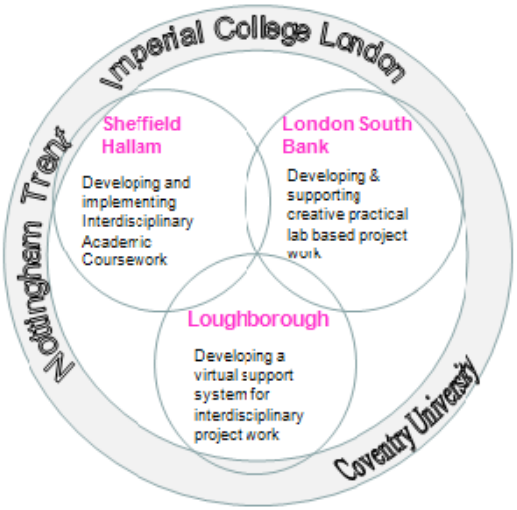
A continuation of this work in the form of a small pilot study in 2009-10 on *"Interdisciplinary and cross year course mentoring & integration",* funded to £3k by the University's Centre for Excellence in Teaching and Learning, investigated inter-disciplinary/ cross year projects linked with a formal project management framework. Results from this indicated that students working on interdisciplinary projects in a multidisciplinary way achieved so much more from their study in terms of progress, project management, peer support, shared development and critical evaluation of their own performance. In particular the interdisciplinary project work provided a real world scenario for integrating single discipline subject knowledge.

4) Current RAE HESTEM Funded Large-Scale Curriculum Innovation and Enhancement Project

This is a twelve month project aiming to build on previous work and to develop an Interdisciplinary Learning Environment that simulates professional practice and develops professional engineering skills in students. It is a collaboration between three main universities with the individual aims to:

- develop an interdisciplinary, cross year peer supported approach to assignment work across courses. (Sheffield Hallam University)
- develop a strategy and support system for multi-disciplinary education (Loughborough University)
- develop multi-disciplinary project based learning developments for laboratory and professional practice education (London South Bank University)

The project is supported by advisors from another three UK universities and the project structure is shown in Fig 3. The overall aims of this STEM project is to develop and evaluate interdisciplinary LTA



Advisors

Imperial College London- will provide advice on skills assessment and on the set-up of cross-departmental teaching initiatives plus institutional cultures & priorities etc.

Coventry University- will provide support from their project activities with multidisciplinary groups in the built environment.

Fig 3 Aims of the STEM Project

Progress to Date:

The STEM funding has allowed the spawning of several mini projects whereby small teams of staff have taken on the development of interdisciplinary coursework across the undergraduate programme's modules as part of the preliminary planning process for incorporation into a forthcoming revalidation of courses for Sept 2013. There are several projects that have been funded for development during 2011/12.

Project 1

This project is concerned with a design competition under the auspices of the Engineers without Borders challenge (EWB). This is being run as part of a first year Technology Foundation module involving physics, mechanics, electrical, fluids and thermodynamics from the EDT portfolio covering a wide range of course disciplines including: Product Design, Automotive Technology and Sports Technology. Coming together on a common first-year module, these courses offer an ideal opportunity to develop cross-disciplinary activity.

Project 2,3 and 4

This project consists of three sub projects all linked into the main proposal for an Engineering Design Incubator. The Incubator consists of a group of engineering companies with requirements for short-term paid contract Design and CAD work which is being undertaken by students as part of their module assignment work or as stand alone work. The work is interdisciplinary and draws upon different courses and students and impacts on different modules at different points in time.

Project 5

A glider simulator has been developed through a number of final year student projects and first year design and workshop practice modules. The work involved to date has been strictly mechanical design, with commercial software being used for graphics and flight mechanics simulation. Advantage is being taken to broaden the student developed content of the simulator and to create a themed platform around which numerous interdisciplinary teaching and project based activities are being developed.

Summary

Sheffield Hallam University has been using interdisciplinary taught academic assignment and project work in a large number of courses for several years to enhance the student learning. Recent interdisciplinary projects aimed at evaluating the use of interdisciplinary work have confirmed its benefits and led on to a large scale curriculum innovation and enhancement project. A group of universities are now working on the Royal Academy of Engineering STEM project in order to embed enhancements of this type across a wide range of universities, thereby enhancing the student experience. The work involves determining and documenting the scope and potential of such developments and how they can be used in taught and project based undergraduate and post graduate modules.

As part of the STEM project, a questionnaire has been given to students at entry and final year which shows a common theme emerging that students want information in different formats, paper and different forms of electronic delivery; and an electronic laboratory book is being developed with multiple access to facilitate group working. Interdisciplinary work is also being developed at first year level around Design and Practice incorporating CAD, professional Skills of written communication, interdisciplinary laboratory work and design.

Discussions with students has also suggested that they like, at least at final year level, to work “outside” their discipline- exactly what the aims of the STEM project hope to achieve.

Some initial multi-/cross-disciplinary ‘proof of concept’ developments will be made during the duration of the project. We look forward to reporting on the overall project outcomes during 2012.

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