

Service-learning experiences: a way forward in teaching engineering students?

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Abstract, engineering education in the UK has slowly starting to understand the benefits of servicing learning as a pedagogical method. The Department of Mechanical Engineering at the University of Sheffield has explored service learning for the past three years.

Previous research by Stukas et al had asked the question, service-learning: who benefits and why? They indicated that there are three main potential 'beneficiaries' of this type of learning: the student, the institution and the community. However, they also argued that none of the potential benefits offered by service learning (learning enhancement, citizenship, fulfilment, employability, reputation, positive impact in the community, etc) is guaranteed and therefore, more research was needed to best determine the factors to achieve the goals and satisfaction of all.

This paper looks at the use of service-learning in an engineering environment both in terms of embedding social awareness into the curriculum and looks at the issues surrounding the engagement of engineering students. The work discusses problems relating to the barriers for successful implementation as well as how service-learning can inspire the next generation of engineers and change the perception of engineering in the community.

Introduction

Universities in the USA have seen an increase in the provision of service-learning experiences since the early 1900s. Service learning has been defined as a credit-bearing learning experience in which students take part in a community or a social project whilst developing some of the learning outcomes of their course (Bringle and Hatcher, 1996). Students involved in service learning courses have repeatedly reported to have benefited more than students not involved in this type of learning. Students have also reported an increase in engagement with their courses, being able to apply their skills in new situations and an enhanced sense of social responsibility (Marcus *et al*, 1993 and Cohen *et al*, 1994). Service learning is not community service; the essential element is that activity is framed within a learning environment (Stanton, 1990). This type of learning is less widespread in the UK and is certainly not widespread practice in UK HEI's, particularly within engineering. However, experiential learning often based around solving a known engineering problem, and with industrial involvement, has in recent years gained much ground (Dutson *et al*, 1997). Service learning is a "balanced approach to experiential learning". (Furco, 1996)

Background

Service learning has repeatedly appeared through the years in the Department of Mechanical Engineering at the University of Sheffield, through group design projects, students' dissertations and research projects. This has been, however, an ad hoc practice that whilst

has helped develop links with the community and expertise within the department, had not been fully established. It was not until 2007 that service learning was consciously implemented in one particular course as a learning approach used to enhance the student learning experience.

As part of their engineering degree within the Department, students have the option of developing a broad range of skills including entrepreneurial and business skills. The capstone project, entitled Technology Strategy and Business Planning, runs in the final year of the four year MEng degree and has grown from the original 'enterprise module' (see Table 1).

Table 1: Evolution of Level 4 module: first phase (Handscombe, 2010)

Year	Students taking module	Module Description	Specific Details	Module Leader reflection
1	28	A module on commercial exploitation, challenging student groups, to devise new commercial applications for a piece of mature university research.		No emotional attachment No technical problem to focus on – emphasis on business venturing No external dimension.
2	43	Merger of the above module with Technology Strategy to create a new 'Business Planning' module where a commercial problem was identified and student teams devised new companies to overcome it.	A representative of Tesco outlined the problem they have with costs and customer complaints regarding wine tainting through corkage. A real technical challenge to devise something different from what currently exists	Good technical challenge Good external interaction from Tesco setting the problem and judging to a team of external mentors.
3	51	As above, but with the problem being identified having a slight social dimension.	A representative of a packaging association outlined the challenges of child proof but easy to use packaging.	Again a real technical challenge, the opportunity of licensable intellectual property and a strong sense that the work was 'worthwhile'
4	55	Focus this year was on a major business problem of a company.	A local company identified its overall business problem and asked for new product ideas	Very little emotional commitment – an unknown company has problems making a profit. No clear technical problem to focus on.

Essential to the module is the concept that the students work in teams to find solutions to a real problem provided by a real customer. The challenge is for the student teams to identify a technical solution to the customer problem and then develop a business proposition from this.

The module is worth ten credits, which is equivalent to a hundred hours of work per student. Students have one double hour session each week during the first eight weeks of the semester. The remaining four weeks are flexible time that students use to develop their ideas and business propositions. During this time students have the support from business and technical mentors. Only 15% of the module is delivered by the module leader the remaining time students are supported by external contributors from a great range of disciplines including business angels, bankers, marketers, business advisors, manufacturers, etc. Table 2 shows an example of the content the module provides, variety of contributors and mentors.

At the end of the course, teams pitch their ideas to an invited audience and defend their poster presentation of their business idea to judges from a mixed background (technical, commercial and legal). Prizes are then awarded to the best presentations. The objective of the module is to give the student an opportunity to try to solve a real problem by combining their engineering knowledge with the commercial constraints that would need to be met in making a business success of their technical solution. It is also an opportunity for students to develop their presentational skills - oral and poster.

Table 2: Example of module timetable (2009)

Topic	Type of delivery	Speaker	Position held	Company	Date	Room
1. Writing your business plan	Lecture	Elena Rodriguez-Falcon	Senior University Teacher	The University of Sheffield	Feb 11	RD14
1. Design for living	Lecture	Alaster Yoxall	Lecturer	SHU		
2. IPR	Lecture	Douglas Drysdale	European Patent Attorney	Murgitroyd	Feb 18	RD14
2. Understanding the customer	Lecture	Louise Hitchings	Marketing Executive	Outokumpu Stainless		
3. The challenge	CUSTOMERS	Staff members	Various	St Luke's Hospice	Feb 25	RD14
		Patient and Wife				
4. Business models	Lecture	Peter Crawford	Solicitor	Taylor & Emmet	Mar 4	RD14
5. Finance sources	Discussion panel	Emma L Turner	Business Manager	HSBC	Mar 11	RD14
		Martin Manning	Business Angel	YABA		
6. Financial statements	Lecture	SIFE representative	Calum Moore	SIFE Ltd	Mar 18	RD14
7. I have done it!	Discussion panel	Will Christopher	Entrepreneur	Will Yaki	Mar 25	RD14
		Paul Thomas	Entrepreneur	Mycorrhizal Syst Ltd		
8. What makes a good business plan.	Lecture	Richard Campos	Managing Director	RC Business Support	Apr 1	RD14
8. Elevator pitches	Lecture	ER-F	SUT	Limited TUOS		
Mentorship scheme (technical and business)						
Business mentorship: by appointment only!	Advice	Amy Jones (Mech Eng), Liz Gillot (BE_SY), Jenny Moore & Toni Cook (Enterprise at Sheffield), Emily Savage, Helen Parrott (WRCETLE)			Email for an appointment or for advice	
Technical mentorship	Surgery	Nigel Harrison	Director	KingKraft	April 29	RD14
ASSESSMENT (Submission deadlines and poster presentation date)						
<ul style="list-style-type: none"> Business plan (50%) Individual effort factor 	Assessment	ER-F	Tutor	TUOS	May 8	General Office
<ul style="list-style-type: none"> Poster presentation (40%) 	Assessment	Customer, academics and business people	Various	Various	May 21	Mappin Hall

The move to service learning

This business planning module has, through the years, moved from the exploitation of the department's research, through working with external clients on real problems mainly in the area of product development, to finally working with the community (Handscombe *et al*, 2008). Originally, the module was centred on the development of a business plan around a piece of research undertaken in the Department, an example being a polarising camera for analysing photo-elastic stress analysis results. Reflection, based on feedback provided by students, on the module practice and learning outcomes showed little engagement with the problem and a poor learning experience.

It was then decided to move the learning approach from the direct 'here is an artefact, write a business plan' to an experiential learning activity based around solving a real problem; the aim of this new approach being to develop increased student engagement, employability skills and meet the module's learning outcomes. Feedback on the module during the next three years showed that the approach of setting a real-world problem to which the students had to provide a solution for as well as develop a business case produced enhanced learning experience. The initial project chosen was based around the development of a new cap or closure for wine bottles. The following year based on another packaging project the students were seen to not only produce high-quality business plans but technology that was seen to have worthwhile intellectual property and generated student driven knowledge transfer into other research areas.

However, all this came crashing down the following year when the project chosen, although a real-world problem, failed to enthuse the students and create worthwhile outcomes across the board. The main problem identified by the students was the lack of engagement of the 'client' and that the focus of the project was more on 'helping the customer make a profit' rather than having the opportunity to use their technical skills and solve the problem. Hence, a better and more cohesive approach was needed to produce a stable learning environment. Table 1 summarizes the projects undertaken and the reflection on the learning outcomes for these years.

It was, therefore, apparent that a new and robust methodology was needed to avoid low student engagement and poor learning outcomes. Based on ad hoc service learning experiences within the Department and the work conducted on research led teaching coupled with the desire to outreach the broader community, that a service learning and teaching framework was developed, which had social enterprise at its core.

Methodology

The methodology developed was several fold. Firstly, it was to move away from the direct technical solution of a single commercial problem. More emphasis was placed on the social need for a business solution. This change came from observation on a research led teaching project that had occurred previously in the Department based on work with a young boy called Kieron who had severe Cerebral Palsy. The student leading the project had shown a great deal of interest in ensuring that the outcomes of the project were exceptional. The student explained that making an impact on the young child would be the best outcome of his dissertation. The 'unusual' engagement of this student with his project helped the authors of this paper develop some hypotheses about using the same approach with large classes. Previous experience had shown that whilst this social context was nothing new, for it to work more effectively it had to be within a formal framework to ensure success. The first step was to look at social enterprise within an experiential engineering education framework. This led eventually to the authors looking at practice within the service learning framework.

Experiential learning and social enterprise

Experiential learning is a continuous process grounded in experience, where learning is developed through adaptation and solving problem activity (Kolb, 1993). The first notion in enterprise learning, within this context, is the significance of 'action', an orientation towards it

and experience derived through it. Action can be split in three parts 'the act of doing'; 'the experience gained in the doing'; and the 'learning accumulated from the experience' (Pittaway *et al*, 2007). It is well accepted that enterprising students engage better in practice through hands-on learning activities or the 'act of doing' (Dalley and Hamilton, 2000; Rae, 2000; Rae and Carswell, 2000; Jones, 2009). It is also an accepted view that engineering students preferred learning style falls within the same remit. (Felder and Silverman, 1998) It is also well understood that learning tends to be more valuable during experience when those engaged in the experience reflect on what they have found (Kolb, 1984; Revans, 1982; DeFillipi, 2001). Kolb (1993) suggests that within this form of learning the student moves from actor to observer and from specific involvement to general analytic detachment. It is during this analytic detachment where sufficient self reflection and critical self-evaluation enables students to develop valid knowledge that go beyond excitement and vain interest in the subject (Barnett, 1990). Therefore, it is critical that students should be presented with different and competing traditions in order to facilitate critical creation as well as critical discovery. (Mendus, 1992).

The service learning format

Having taken all of the above into consideration and 'curious' about the 'unusual' engagement the student working with Kieron had shown, the authors explored an extension of experiential/social enterprise learning; service learning. As explained earlier, service learning is an assessed learning experience in which students take part in a community or a social project whilst meeting the course objectives (Bringle and Hatcher, 1996).

Kathleen Mass Weigert (1998) in her book chapter 'Academic Service Learning: Its Meaning and Relevance', provides six elements of academic service learning, which became the basis for the new modules format:

- The student provides meaningful service
- The service that students provide meets a need or goal of some kind
- Members of a community define the need
- The service provided by students flows from course objectives
- Service is integrated into the course by means of an assignment (s) that requires some form of reflection on the service in light of course objectives
- Assignments rooted in the service must be assessed and evaluated accordingly

Consequently, these new modules were to have:

- A strong social element
- Clear interaction between students and customer to define the need
- Interaction with the wider community
- Clear understanding of professional and civic responsibilities and consideration of ethical issues
- Opportunity for social enterprise
- Reflection of learning outcomes and social impact (both students and staff)
- Dissemination of practice to move from the ad hoc approach

All of these considerations were deep-seated in the modules learning outcomes and assessment of the students. Assessment remained the same as before, however, an element of reflection was added to ensure that the experiential/service learning approach was completed.

The service learning years

"Kieron's Challenge" was the first of these new module formats. In this challenge the brief was quite simple, to make his life easier. The solutions devised by the students were driven by the needs and wants of this seven year old boy, his family and carers. Further, the ideas generated backed up with sponsorship from other local companies had the potential to be developed into real commercial enterprises. Hence, there were significant 'pushes' and 'pulls'

and the students to engage with the project. Central to this was meeting and interacting with Kieron and his family as can be seen in Figure 1.



Figure 1: Students meeting Kieron and his family

The following year the project was based around wants and needs of the Sheffield Children's hospital and their patients. And in 2009, students were faced with yet again another social challenge; 'adding quality of life' to terminally ill patients at the local hospice. Figure 2 shows the winning team discussing their solution with the hospice patient. Again, in these both years students were heavily engaged with users and their problems and some solutions were generated and prototyped. A summary of the projects and reflections of these are shown in Table 3.

Table 3: Evolution of Level 4 module: second phase

Year	Students taking module	Module Description	Specific Details	Module Leader reflection
5	70	Focus on a specific need of a specific individual.	A boy with cerebral palsy is interviewed by the whole class and outlines what he can do and what he would like to do.	Huge emotional commitment to find technical solutions to the boy's problems and limitations. Ideas worked up well technically and prototypes are being manufactured but focus moved to technical aspects of product development and away from new venture development
6	87	Focus on supporting a local children hospital	A representative for the children hospital and a patient are interviewed by the whole class and outlines the problems in the occupational therapy and rehabilitation department.	As above, huge emotional commitment to find technical solutions to the children's problems and limitations. Ideas worked up well technically and prototypes are being manufactured. Students from the course volunteered extra-curricularly to solve other problems.
7	97	Focus on supporting a local hospice	A representative for the hospice and a patient are interviewed by the whole class and outlines the problems faced by the hospice whilst providing care for their patients.	As above, huge emotional commitment to find technical solutions to the children's problems and limitations. Ideas worked up well technically and further research is being conducted.
8	144	Focus on supporting a local school for children with special needs	No data available yet	No data available yet



Figure 2: St Luke’s patient with winning students at poster presentation

For 2010, the project has been set up and will focus on enabling a better learning experience for children with learning difficulties and disabilities at a local school with special needs. Although, the course is yet to be delivered students registration records show a record number of 144 students who will be taking the course.

Framework evaluation and analysis

The service learning framework has been running for three years now and sufficient data has been gathered to have a meaningful evaluation and analysis of its impact in the student learning experience. The study sought to explore whether student engagement and attainment had been impacted in any way after introducing the service learning approach. This was achieved by conducting a questionnaire at the end of the module, through the analysis of non-requested feedback and by comparing students’ attainment before and after service learning was implemented. Key findings from the questionnaire are summarised in Table 4.

The methodology applied does have some weaknesses, for example, the questionnaire response rate each year was about 50-60% and another limitation is that the evidence collected and used depends on self reported learning and as a consequence, the data do rely on the students’ own impressions of their learning experience. Consequently, a second part of this analysis was conducted by gathering data on other impact measures such as student numbers registered each year, number of contributors engaging with the module, etc. Table 5 provides a summary of these impact measures.

Table 4: Key findings from questionnaire

High satisfaction level with: (%)	Pure experiential learning			Service learning		
	2004	2005	2006	2007	2008	2009
Module in general	74	78	62	89	87	87
Project	75	77	45	92	89	93
Assessment	76	75	70	78	77	80
Perceived learning achieved	70	72	68	77	78	79
Professional outcomes	65	63	25	77	76	77

Table 5: Impact measures

	Pure experiential learning			Service learning		
	2004	2005	2006	2007	2008	2009
Student numbers	43	51	55	70	87	97
Student interview with clients (time in min)	25	30	25	80	80	85
Number of contributors	3	4	5	8	15	17
Sponsorship for prizes	150	250	250	1000	750	750
Products prototyped				1	1	Ongoing (2)
Media interest				Yorkshire Post, The Sheffield Star and BBC Website. Interview BBC Look North	Yorkshire Post, Sheffield Telegraph. Interview BBC Radio Sheffield.	Yorkshire Post (2), The Sheffield Star
Extra-curricular projects				1	1	
Teaching awards and grants				RAEng, Teaching Award, £10,000	RAEng, ExxonMobil Teaching Award, £10,000	TUOS, BiC grant £10,000.
Non-requested project					x	x

Discussion

Whilst Table 3 presents a pretty conclusive picture in that it is clear that service learning appears to increase significantly pretty much across all the criteria assessed, it is also clear that when it comes to their assessment and perceived learning, levels do stay very much at the par with previous years. However, when analysing the hard figures in terms of the module's results it can be observed that during the past 3 years the marks have increased by a factor of 5% average.

It can also be seen that the nature of the project has also played an important role in enhancing student engagement and satisfaction overall. Having said this, students motivations for taking this module vary significantly at the start of the course. Reasons are evenly split between developing business skills, increasing employability skills, because of the project and because is coursework!

By the end of the course, however, is not uncommon to receive non-requested feedback such as the one from this student that for the purpose of this paper we will call Matt:

"I enjoyed the course very much and I am glad I decided to opt for this module. It gave me a great understanding about business planning but above all, helping others to lead a better life with our innovations and designs.

This is my best module so far. "

The question about personal outcomes is specifically phrased as "how much do you think the experience of participating in this project will positively affect your professional prospects". This particular question has been included since the beginning to evaluate the students' perceptions of their employability skills as a consequence of the module. Results show that students tend to expect positive outcomes from having taken part in this type of project.

Although, an investigation on how this module has actually affected students' employability prospects has not been taken, there are some limited pieces of evidence (2 students per year in average) in the form of non-requested feedback. An example of this is shown below, after a few months of the module concluding this student who we will call Liam emailed and said:

"I just wanted to let you know that I was successful in my job interview. It was incredible; most of the interview was focused on the Sheffield Children's Hospital Challenge! Thank you so

much for ensuring that we have such type of project, otherwise I might have not got the job!"

The second part of the analysis is based on several impact measures that have been gathered in Table 4. Student numbers opting to take the module have doubled since 2004 and more than trebled since 2003. Similarly, contributors involved in the course such as bankers, marketers, lawyers, etc have significantly increased over the years. Arguably, some of these contributors have remained loyal to the module, whilst others have joined over the years. Making a difference, contributing to people's well-being and to the community and doing good are traits that remain part of our desires and conversations, we worry together about what is happening to us? What can we do? (Mass Weigert, 1998).

Sponsorship for prizes showed a 300% increase on the year of the Kieron's challenge, this can, arguably, be attributed to the fact that organisations involved saw this as an opportunity to gain some press attention, which also suddenly seemed to appear out of the nothing and has consistently stayed there during the following years.

Other impact measures that can be analysed include teaching awards and grants received by the module tutor as a consequence of this learning approach. This evidences the interest that the academic and industrial community is increasingly showing in this type of learning approach.

The last impact measure and perhaps the most important one is the level of student engagement with the customers. Customers have an interview with the whole group of students at the beginning of the module. During this interview students ask questions in order to determine the customer's needs and the criteria they need to meet to demonstrate at the end that they achieved this goal. As it can be seen in Table 4, interviews which are recorded and timed, have lasted up to four times longer in the last three years. Witnessing this type of interaction, where students use their technical skills to understand the problems, professionally and ethically approach any sensitive issues but most of all, listen carefully to the community engaging with them is one of the most rewarding experiences for any learning facilitator. In 2007 and 2008, some students out of the whole group also offered their volunteering services to conduct other projects outside their learning environment. Lastly, during the two years and also for 2010, projects have been offered to the Department by community sectors looking to engage with the University and for help.

Conclusions

In 1999 Stukas *et al* asked the question, service learning: who benefits and why? They indicated that there are three main potential 'beneficiaries' of this type of learning: the student, the institution and the community. However, they also argued that none of the potential benefits offered by service learning (learning enhancement, citizenship, fulfilment, employability, reputation, positive impact in the community, etc) is guaranteed and therefore, more research was needed to best determine the factors to achieve the goals and satisfaction of all.

This paper asks the question is service learning a way forward to teaching engineering students? Notwithstanding Stukas *et al* arguments, the authors of this paper would like to conclude that service learning has proved to be a definite improvement on previous learning approaches. Although, there are barriers to embed this type of learning method such as organisational issues, learning agreements, deliverables and ethical considerations, the benefits observed during the past three years have been considerable to the three main stakeholders in this process.

- The student: increased satisfaction, engagement and possible increased employability.
- The institution: increase level of engagement with the community, external contributors and recognition through media attention and awards.

- The community: engagement with the University, problems tackled and some solutions developed. Increase sense of receiving help and also of helping the student learning experience.

On this last point, the authors would like to conclude with a non-requested email from a member of staff of the local hospice who, after the module had finished, contacted the department with sad news of the death of the patient who had contributed to the course, who for the purpose of this will be named George and his wife Esther.

“Just to let you know that George died last Wednesday. Unfortunately, over the last few weeks George had become increasingly muddled and Esther was unable to manage him at home. After a long stay in St Lukes, George died in a nursing home. It was George’s funeral yesterday and Esther wanted everyone to know about George taking part in the University project and how much this meant to both of them particularly coming to the University and answering the student’s questions. Esther could not quite believe they had wanted to know about her as well!”

Esther was happy for me to let you know about George and I wanted you to know how much they both valued taking part in the project and the memory you left Esther of that time.”

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