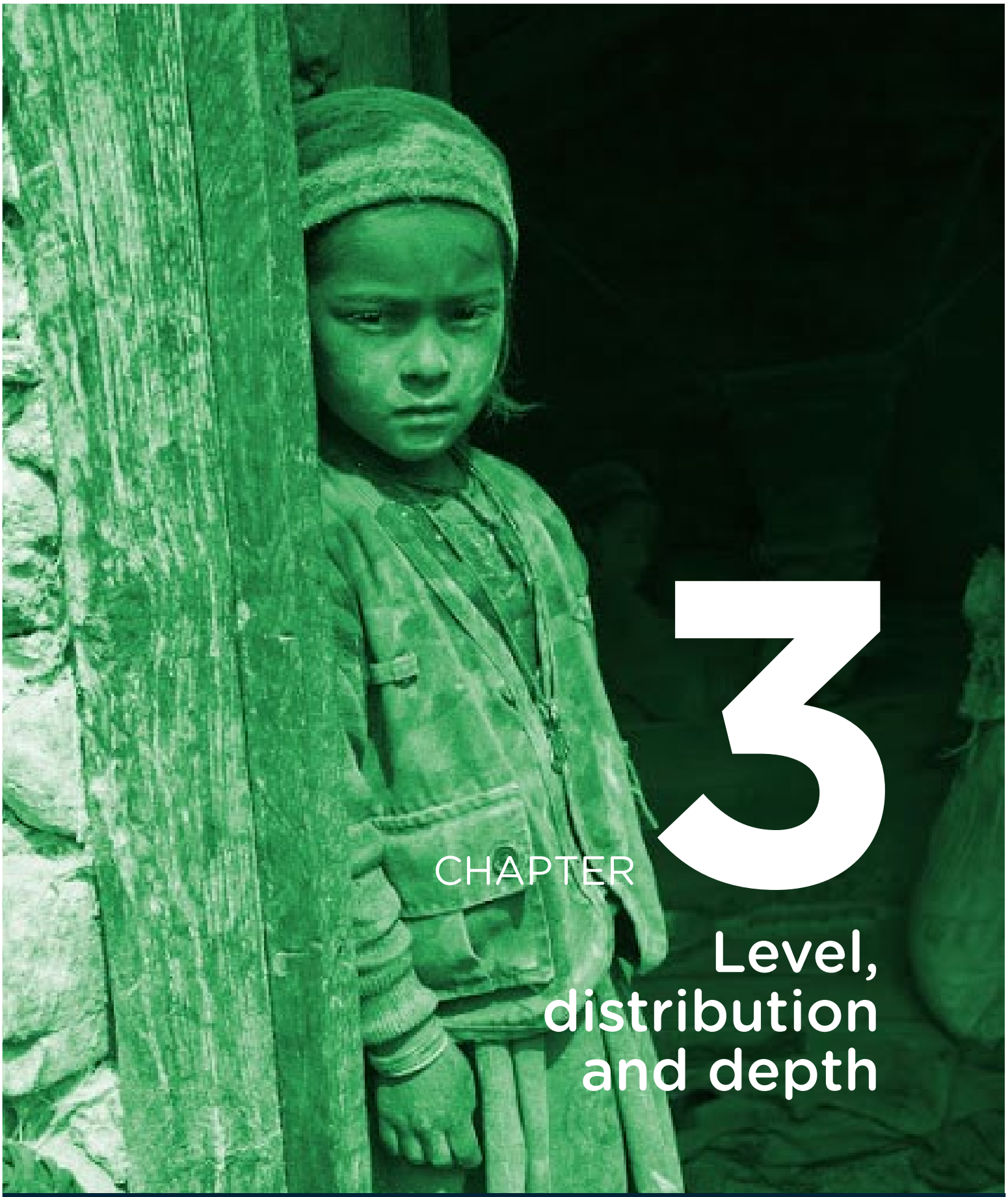

CHAPTER 3

Level, distribution and depth

PHOTO: A Child Works With Her Mother in a Water Powered Flour Mill, Dhorpatan, Western Nepal. D. Narayanan

3

CHAPTER 3. Level, distribution and depth

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Global Dimension in Engineering Education

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3 LEVEL, DISTRIBUTION AND DEPTH

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EXECUTIVE SUMMARY

The Global Dimension can be integrated into the different levels of academia in a variety of ways, and with different breadth and depth. This chapter uses real examples to present and discuss methods for introducing the Global Dimension. In particular, it uses examples of Service Learning to show how the Global Dimension can be integrated at levels ranging from undergraduate modules to post-graduate research.

This chapter introduces ideas that can be used to stimulate student learning by presenting innovative modules and case studies of Service Learning such as: community-based projects; multi-disciplinary projects; partnerships with NGOs for students to work in developing countries as part of their degree programme, and; multi-disciplinary teams to support PhD students in addressing community needs.

By considering the advantages and disadvantages of each method – and the contexts in which they can be used – the chapter demonstrates how the right method for introducing the Global Dimension can be selected for the right context. By taking examples from the National University of Ireland, Galway in Ireland, this chapter gives a sense of the level, distribution and depth that can be achieved when Global Dimension is taken into the core of academia through the lens of Service Learning. Key success factors of embedding Service Learning in curricula are summarised.

LEARNING OUTCOMES

After you actively engage in the learning experiences provided in this module, you should be able to:

- Describe different ways the Global Dimension can manifest in the curriculum in a practical way that fits the stakeholders' needs, capabilities and capacities.
- Recognise and explain the advantages / disadvantages of each manifestation.
- Select the most appropriate method of integration for a variety of situations.

KEY CONCEPTS

These concepts will help you better understand the content in this session:

- Project-based Learning and Service Learning
- Community engagement
- Self-guided learning
- Academics as facilitators

GUIDING QUESTIONS

Develop your answers to the following guiding questions while completing the readings and working through the session:

- How would this work at my university, and what would need to change in terms of culture and support?
- What student/ group/ class projects exist in my university that could be adapted to take a Service Learning approach, whilst not diminishing engineering content?
- Are my students ready for this? And am I ready for this?

INTRODUCTION

The Global Dimension can be integrated into academia in a variety of methods. For example, the 'Global Engineer' is a concept developed by Bourn and Neal (2008) that steers engineering education in 'global' directions (in response to a combination of global challenges such as sustainable development and poverty reduction) and highlights the need to foster 'global skills' and incorporate new methodologies that enhance student learning.

The overall context for the Global Engineer is one that is both challenging and promising. Taking the example of Ireland, Bourn (2009) notes some interesting priorities and trends. Firstly, there is evidence of a more 'ethical-based approach to engineering', as reflected in the Institution of Engineers Ireland Code of Ethics and the presence of linkages between engineering and development ((Bourn 2009), citing Institute [sic] of Engineers in Ireland 2003 & Institution of Engineers in Ireland 2004). However, Bourn's report (Bourn 2009) also finds that sustainable development does not appear to have a high profile in Irish engineering education in comparison to, say, the United Kingdom or Germany.

This chapter presents ways in which the Global Dimension has been implemented in engineering education in tertiary-level institutions in Ireland. 'Soft skills' and new teaching and learning approaches are core to the Global Dimension agenda and core to its framework of generic themes, skills and dispositions. Within National University of Ireland (NUI) in Galway, we identify civic engagement and social responsibility to be the principal lens through which the Global Dimension is taking root and developing. Service Learning (also known as Community-Based Learning) as a pedagogical tool provides a means of connecting students' academic study with the context of community and society, with the explicit intention of promoting active and responsible citizenship (Bringle & Hatcher, 1996; Furco & Holland, 2004; Zlotkowski, 2007). Since 2003, Service Learning has been used as a pedagogical tool in the College of Engineering & Informatics at the NUI Galway. All students undertaking engineering degree programmes at NUI Galway (as well as some postgraduate Engineering students) complete at least one Service Learning project during their course. This means more than 200 students complete these projects each year (see Table 1 and the next section for further details). These projects are framed by a research orientation, commitments to civic engagement and building university-community partnerships, city-university partnerships and partnerships with other official agencies. Such framing means that community users can provide real learning problems and contexts for students, and researchers can benefit from the results.

This chapter will explore Service Learning as a pedagogy tool for the Global Dimension across engineering education, by presenting details of its implementation at NUI Galway. It will highlight how the approaches outlined fit well with the ideas of engaged scholarship (Boyer, 1996) and civic professionalism (Sullivan, 2005). The evaluation of Service Learning

modules in engineering at NUI Galway highlighted that the students come to value consulting the end-users of their designs and recognise the long-term value of engaging with community partners. This is also connected with a new understanding of their future role in the community as engineers, reinforcing the idea that their work can respond – and should respond – directly to real needs in the community.

WHY EMBRACE THE GLOBAL DIMENSION IN ENGINEERING EDUCATION?

Recent research and reports (Royal Academy of Engineering, 2007; Jamieson & Lohmann, 2009; Sheppard et al, 2009; Atman et al, 2010) have shown that there is a critical need to provide students with a deeper understanding of the general concepts and principles of engineering, and to provide them with the means to meet the challenges of the 21st Century. One such report by the Royal Academy of Engineering (2007) highlighted the need for "*university courses to provide more experience in applying theoretical understanding to real problems*".

Service Learning provides such an opportunity. The project modules are based around the student groups developing innovative technology for real-world problems. They use a design process that involves close interaction with end-users to understand their needs and to repeatedly get feedback on the suitability and usability of their design concepts.

Evidence has been collected from the aforementioned projects at NUI Galway which shows that, by creating Service Learning, the students' energy in learning can have a positive impact on the community and the students. Their energy and enthusiasm can be better utilised (and increased) by setting assignments as real community-based projects. The students get a sense of pride and satisfaction out of the knowledge that their work may be helping communities (and that learning is not just to get marks to pass the exam!). The projects can increase the students' sense of ownership of their own learning. Learners are more motivated when they can see the usefulness of what they are learning, and when they can use that information to do something that has an impact on others (Bransford et al, 2000 and Goggins, 2012). The projects allow the students to achieve all of the programme outcomes that the engineering professional body has specified for an accredited engineering degree (College of Engineering & Informatics, 2012). Furthermore, there is evidence to show that such engagement can lead to a widening of participation to include greater numbers of women and minorities in both engineering education and the engineering profession (Oakes, 2008).

As seen from Table 1, and highlighted further in the following sections, the College of Engineering & Informatics at NUI Galway has embedded civic engagement across all its undergraduate programmes through local and international community-based engineering projects.

Table 1 *Service Learning initiatives introduced to Engineering & Informatics in NUI Galway:*

Module	Programme	Year	Number of students each year	Number of community partners
CAIRDE (see page 9)	BEng in Biomedical Engineering; BEng in Mechanical Engineering.	3rd	70	> 20
CE226 Principles of Building: community-based engineering project (see page 11)	BEng Civil Engineering; BEng Environmental Engineering; BSc in Project and Construction Management; BEng in Energy Systems Engineering.	2nd	70 to 130	> 25
EE325/EE326 Third Year Project Module (see page 14)	BEng in Electronic and Computing Engineering; BEng in Electrical and Electronic Engineering.	3rd	35	5
Professional Studies in Electronic Engineering and Electronic & Computer	BEng in Electronic Engineering; BEng in Electronic and Computer Engineering.	3rd	12	10
Managing Development (see page 15)	BEng Civil Engineering; BEng Environmental Engineering; BSc in Project and Construction Management; MA in Environmental, Society and Development (Geography).	3rd yr (undergrad Engineering); 1st yr (postgraduate Geography)	170	38
Engineering for Humanity – professional field placements (see page 17)	BEng Civil Engineering; BEng Environmental Engineering; BSc in Project and Construction Management.	3rd yr	8	2
Final year project	BE Civil Engineering; BE Environmental Engineering; BSc in Project and Construction Management.	4th yr	10	2
Information Technology Project	Masters in Information Technology.	MIT	12	8
Engaging with the community: research practice and reflection (see page 19)	Structured PhD in College of Arts, Social Sciences and Celtic Studies; Structured PhD in College of Engineering & Informatics.	MA / MEngSc / MSc / PhD	10	2

COMMUNITY-BASED PROJECTS: A LENS THROUGH WHICH TO IMPLEMENT THE GLOBAL DIMENSION IN ENGINEERING EDUCATION

This section introduces ideas that can be used to stimulate the students learning, by presenting innovative modules and project-based learning case studies such as:

1. Community-based projects (also known as Service Learning);
2. A multidisciplinary project called 'Managing Development';
3. 'Engineering for Humanity', which is a joint initiative with NGOs to give undergraduate engineering students the opportunity to work in developing countries as part of their degree programme, and;
4. 'Engaging with the Community: Research Practice and Reflection', which is the first module of its type in Ireland and gives PhD students the option of working in small multi-disciplinary teams to address the needs of voluntary or community organisations (a credit-bearing module in a postgraduate research programme).

These initiatives allow students to complete engineering research projects in the community. Students are therefore 'learning by doing'. Some specific examples relating to Service Learning are given in the following subsections.

Moving project modules from a more traditional approach – of projects based solely around an academic's or student's area of interest – to one driven by Service Learning and partnering with community organisations acts to enhance student engagement through the real-world nature of the technical problems being addressed. This is in addition to the opportunity to work with groups that are often excluded from many technology innovations (due to cost or poor design).

The modules are individually tailored for the group of students, taking account of their previous learning experiences, size of group, programme, diversity and so on. The modules are carefully designed to ensure there is no loss in the technology learning outcomes, whilst students gain significantly in terms of: understanding the role of the engineer in society; the need for a tight and inclusive design cycle to address user requirements, and; the importance of cost in terms of adoption of the solution in the target consumer group. Service Learning fits well with the descriptors for the six Programme Areas outlined in the Institution of Engineers Ireland Accreditation Criteria for Engineering Education programmes, including "*responding to real life situations*" and "*developing awareness of the social and commercial context of engineer's work".* The quality and impact of the projects was specifically praised by the accreditation board during their visit in 2012. The College of Engineering & Informatics at NUI Galway was shortlisted for the 'Best in Class' award at Institution of Engineers Ireland Awards in 2013 for work in Service Learning.

1. Community-based projects: University support

Service Learning is currently seen as having priority within higher education in Ireland. According to Byrne & McIlrath (2011), this priority has been prompted by the 'Celtic Tiger' phenomenon where the 1990s brought a profound change and Ireland benefited from an economic boom. Coupled with this wealth was a growing concern over perceived declines in levels of 'social capital'. To counteract this, there was recognition of the potential role that Service Learning (as well as other civic engagement strategies within higher education) could play in redressing the balance (Boland & McIlrath, 2007).

The first formal commitment to increasing social capital through civic engagement came in NUI Galway in 2001. With the support of a number of benefactors (including Atlantic Philanthropies) the 'Community Knowledge Initiative' (CKI) was established within the university. This initiated '*the creation of a radical new approach to the betterment of society through emphasis on three core elements of community-based research, service learning and knowledge-sharing*' (Community Knowledge Initiative, 2001, p2). The CKI was subsequently afforded prominence within the institution's Academic and Strategic Plans (2003-2008 and 2009-2012) (National University of Ireland, Galway, 2002, 2008). This funding allowed the university to employ personnel to work on both mainstreaming civic engagement within the curriculum across the university (Service Learning) and also on encouraging and supporting extracurricular (student volunteering) activities. Each year, the CKI undertakes a community needs analysis whereby the community document their needs related to the disciplines that contain a Service Learning experience. These needs are subsequently mapped to members of faculty and this process ensures that the university is responding to a direct need and not saturating the community sector with an over-abundance of Service Learning students. Since the inception of the CKI, over thirty academic degree programmes have incorporated Service Learning experiences.

Since 2003, Service Learning has been used as a pedagogical tool in the College of Engineering & Informatics at the NUI Galway. For example, in 2003, a Service Learning module was established in a post-graduate degree programme called the Masters in Information Technology (MIT) (Byrne & McIlrath, 2011). In the same year, Service Learning was introduced into the BEng in Mechanical Engineering and BEng in Biomedical Engineering as a required component (called 'CAIRDE') of the mandatory third-year module 'Engineer and Society', which is now also a module also taken by Electronic Engineering students. Wallen and Pandit (2009) outline the benefits of introducing civic engagement into biomedical and mechanical undergraduate programmes at NUI Galway. Since then, the College of Engineering & Informatics at NUI Galway have gone further and implemented a number of initiatives in their civil engineering undergraduate and post-graduate degree programmes to allow students to complete engineering projects in the community.

1(a). Community-based projects: Biomedical and Mechanical Engineering

The Mechanical and Biomedical Engineering degree at NUI Galway has a Service Learning module incorporated into its programme, giving students experiential learning while applying academic knowledge. 'Community Awareness Initiatives Responsibility-Directed by Engineers' (CAIRDE) was designed as a way for students to identify a need in their community and define a project with very distinct goals (Wallen & Pandit, 2009). It brings together subjects such as 'Engineering in Society', ethics and community outreach and involves 18 hours of lectures, 8 hours of tutorials and 16 hours of service over two semesters. It is credit-rated with 6 ECTS.

Extract from Table 1 *Summary of CAIRDE:*

Module	Programme	Year	Number of students each year	Number of community partners
CAIRDE	BEng in Biomedical Engineering; BEng in Mechanical Engineering.	3rd	70	> 20

CAIRDE is a pioneer programme for Service Learning amongst engineering students in Ireland. It has been recognised internationally as an exceptional student community engagement initiative by being awarded a MacJannet Prize in 2010. Since the programme's inception more than 500 students have taken part in Service Learning projects, devoting over 8,000 hours of service to local communities. The students have made tremendous strides in taking an active role in society and have gained strong relationships with their community partners. CAIRDE has enabled students to build a link between the university and community, showing how collaboration between the two can yield positive results that are reciprocally beneficial.

Students of the CAIRDE programme are expected to take on a great deal of responsibility in the facilitation of their Service Learning project. They must develop a project that enables them to utilise their engineering skills to address a real need for an individual or group in the broader community. By putting this knowledge into action, students work directly with the beneficiaries and must ensure that their needs are met through the work conducted. Projects vary in terms of the beneficiaries and type of work students engage in. Some may work with established organisations (such as Enable Ireland, Saint Vincent de Paul, The Simon Community, National Council for the Blind and The GAF youth cafe). Others direct their efforts towards supporting local schools, nursing homes, hospitals, libraries, playgrounds and athletic clubs. Some students choose to address the needs of a specific individual by either contributing to personal care or improving someone's quality of life. The success of

these projects has gained CAIRDE such great recognition that the number of community organisations wishing to collaborate with the programme continues to increase.
CAIRDE demonstrates the value of Service Learning, as it requires student participants to use and develop ‘soft skills’ that are invaluable to engineers but often difficult to teach in a traditional classroom setting. These ‘soft skills’ include project management, task analysis and interpersonal skills as well as practicing shared decision-making and being able to reflect on their learning and experiences. Additionally, the students are able to apply knowledge to a specific, real project for the first time, which helps them to view their academic preparation in a new light. All the while, CAIRDE is fostering a greater understanding of community needs and what methods can be taken to address these needs.

CAIRDE places great emphasis on how the students understand their impact on society. Therefore, reflection plays a central role to the Service Learning process. In the reflection process, students tie in what they are learning about the community as well as how they can further develop their engineering skills. Students share this reflection with the greater educational community, building awareness and demonstrating to their peers how they can make a difference in their communities.

1(b). Community-based projects: Civil Engineering

In the second year community-based engineering project, students must form small teams, identify a suitable community partner and sign a 'learning agreement' with their community partner. The learning agreement clearly outlines the goals of the project and tasks involved in completing the project, as well as the learning outcomes for the students. The outcome of the project is a written technical report, which is sent to the community partner. The specific aim of the project is to fulfil a real need of the community partner that relates to the associated module taken by the students 'CE226 Principles of Building'. The project takes about 100 hours over one semester and is credit-rated with 5 ECTS.

Extract from Table 1 *Summary of the community-based engineering project:*

Module	Programme	Year	Number of students each year	Number of community partners
CE226 Principles of Building: community-based engineering project	BEng Civil Engineering; BEng Environmental Engineering; BSc in Project and Construction Management; BEng in Energy Systems Engineering.	2nd	70 to 130	> 25

Some community partners and community-based projects are identified by the instructor. However, the onus is on the students to identify suitable community-based projects. The 'learning agreement' must be submitted by the students within 2 weeks of starting the project. In addition to the set learning outcomes for the project, the students must also decide on three additional learning outcomes that relate to this component of year's work.

Marks are allocated for the technical context and presentation of a written report and oral presentation. Marks are also allocated for the level of engagement with the student's community partner and for producing a report or outcome that relates directly to a real need in the community. The students must each complete a self-assessment marking sheet at the end of the project, which is marked by a grader (a postgraduate student or lecturer). The criteria in the self-assessment sheet relate to the learning outcomes.

Lectures and workshops are held during the semester on effective communication, facilitated by a consultant in public relations. Postgraduate students act as mentors by hosting weekly drop-in centres for students to give technical and report or presentation advice. Objectives set for the students in the project's 'Mini Group Project' guidelines include (Goggins, 2012):

- Develop engineering skills through a self-directed project
- Apply knowledge or skills learned in the module (and others) to a real context

- Develop a sense of commitment to local communities by making a contribution of time and expertise to an individual or community group
- Learn how engineers make contributions to their communities in their careers
- Produce a technical engineering report
- Deliver a high quality oral presentation on a particular subject

An award has been introduced for the best community-based project. Shortlisted projects are presented by the students to their peers, academics and the wider community. The project judged by those in attendance to be the best receives the award.

Structured community partner feedback was also captured through surveys so as to develop guidance on best practice in community-based engineering projects. For example, in 2012, 17 of around 30 community partners completed the survey and 82% of them were either ‘very satisfied’ or ‘satisfied’ with student compliance to project aims, goals and objectives. Strict adherence to the signed learning agreement was clearly of benefit. Such a ‘contract’ document maintained the link to the initial plan. Additionally, the drop-in clinics were of benefit to students and ensured focus was continually redirected back to the signed learning agreement, as found from student feedback. When asked to rate the usefulness of the student report findings, 92% of community partners selected ‘very satisfied’ or ‘satisfied’ and 94% of surveyed partners said they intended to implement the findings. The surveys demonstrate that the vast majority of the students fulfil the main aim of their project; that is, to identify and satisfy a real engineering need of a community partner. Some of the very positive comments from community partners are also received through these surveys.

Grouped student evaluation surveys in 2011 showed that students liked getting involved with and working for organisations or individuals in the community. Out of 40 groups of students, 21 groups responded that they obtained an increased knowledge and understanding of the project topic, 3 groups thought they gained a better understanding of the overall content of the course and 16 groups said they gained by completing a project on real world applications (the students were asked to document the group’s opinion and consensus in five questions).

Salient features of the set-up of the community-based engineering project are:

- Detailed and structured guidance for students and community partners
- A structured learning agreement that must be completed by the students and their community partner at the start of the project
- A self-assessment sheet and marking sheet for graders that is available to the students and is in line with the learning objectives of the project, so that it is clear to the students what is expected of them

- Marks are returned to the students with feedback within 2 weeks of submission of the project and before the end of the semester
- The reports are sent to the community partner and they are asked for feedback

Race (2007) gives some good advice on designing student projects. One suggestion is to work out specific learning outcomes for the projects. Race (2007) suggests that "*these will be of an individual nature for each project, as well as including general ones relating to the course area in which the project is located*". Each year there are approximately 50 to 60 individual community-based engineering projects completed by second year civil students (with one or two academics facilitating this). Therefore, it would not be feasible to write learning outcomes of an individual nature for each and every project. Following Race's advice, general learning outcomes are set for all projects and students write 2-3 learning outcomes that are specific to their project. This gives the students' scope to adjust the learning outcomes to suit their desired learning – and increases their sense of ownership over their learning (which is in the ethos of the project). Sample projects from previous years are made available to students. Seeing the standard of completed projects encourages students to at least meet, if not surpass, this standard.

Having staged deadlines for the project is very useful, such as for agreement of the learning outcomes with the community partner (this is also good practice for their future careers).

The students present their mini-projects both orally and in a written technical report. As well as receiving feedback on their written report, they also receive strong feedback on oral presentation skills from an external consultant in public relations. A question-and-answer session at the end of the presentations is used as both an assessment and feedback tool on technical capability. Questions are used to further assess the students' depth of knowledge. Instant feedback is given to the students on misconceptions or gaps in the knowledge. "*The significant feedback of learning and the potential of formative assessment to enhance pedagogy (York 2003) provide a strong argument that all assessment activity in universities should aim to provide effective feedback for students. Indeed, feedback is arguably the most important aspect of the assessment process in raising achievement (Black and Williams 1998; Gibbs and Simpson 2004)…*" (Bloxham & Boyd, 2007, p103).

The students' self-assessment evaluation is not currently taken into account in the final marks. However, there are many advantages to using both self-assessment and peer-assessment, which include making students aware of the characteristics of 'good work', encouraging them to take responsibility for their own learning, and encouraging them to reflect on themselves as learners and so learn how to learn (Race, 2007).

1(c). Community-based projects: Electrical and Electronic Engineering

All third year students in the Electrical and Electronic Engineering discipline within the College of Engineering and Informatics undertake Service Learning group projects. These usually involve the development of technology prototypes for the clients of various community organisations (such as the National Council of the Blind, Deafhear, Enable Ireland and organisations active in supporting homeless people and victims of domestic abuse). The project takes 50 hours over six months and is credit-rated with 5 ECTS.

Extract from Table 1 *Summary of the community-based engineering project:*

Module	Programme	Year	Number of students each year	Number of community partners
EE325/EE326 Third Year Project Module	BEng in Electronic and Computing Engineering; BEng in Electrical and Electronic Engineering.	3rd	35	5

Technology prototypes are the main focus of these projects because of, quite simply, the nature of the technology. Example projects include: ‘Rowmate’, a smartphone app that allows visually-challenged individuals to utilise and interact with screen-based indoor rowing machines; a system to allow older people with memory problems to manage the process of taking daily medications, and; the development of a solution to allow children with little or no limb control to interact with video games.

The project raises awareness amongst the students of how their design work and decisions can have very positive impacts on the lives of some groups within society. It teaches them to consider the issue of inclusivity when making a design decision by putting themselves in the place of a wide range of different potential users. A public poster event highlighting the projects takes place every year.

Further details can be found in a peer-reviewed conference paper by Liam Kilmartin (Kilmartin, 2010).

2. Multi-disciplinary projects

Collaboration between colleagues in Civil Engineering, Geography and CKI led to the introduction of an interdisciplinary project in 2010 into a number of programmes in NUI Galway. This multi-disciplinary module, entitled 'Managing Development', links the MA in Environment, Society & Development (Geography) with the BEng degrees in in Civil and Environmental Engineering and the BSc in Project & Construction Management. It involved 19 students from the School of Geography and Archaeology and 150 students from the College of Engineering and Informatics. It is a 60-hour module for undergraduate engineers (200 hours for postgraduate Geographers) over one semester, and is credit-rated with 3 ECTS (undergraduates) and 10 ECTS (postgraduates).

Extract from Table 1 *Summary of Managing Development module:*

Module	Programme	Year	Number of students each year	Number of community partners
Managing Development	BEng Civil Engineering; BEng Environmental Engineering; BSc in Project and Construction Management; MA in Environmental, Society and Development (Geography).	3rd yr (undergrad Engineering); 1st yr (postgraduate Geography)	170	38

The idea for the module was initially developed because faculty were keen to introduce approaches to teaching that would engage students with communities in a practical and meaningful way. Engineering and Geography clearly presented a number of dimensions for successful collaboration. This module complements the engineering projects that the engineering students carry out with community partners in the second year of their programme. Third year civil engineering students are also given the opportunity to work in developing countries with NGOs as part of their professional experience programme (see 'Professional engineering placement in developing countries' example below).

The module involves mixed groups of Geography and Engineering students developing critiques of a selected range of NGOs. Their task is to produce a set of evaluation posters which assist these NGOs in identifying strengths and weaknesses, and thereby contributing towards the improvement of approaches used in particular activities. The format provided an active learning environment for students, enabling them to apply classroom-based learning to an actual organisation in order to: identify how or whether such concepts and approaches are being interpreted and applied in a real-life setting; comprehend the potential gap between theory and practice in a real-life situation, and; suggest whether and how examples of actual policy and practice might be redefined and improved. This project-based approach

involves students adopting specific roles as part of a team, collaborating with one another to devise the project structure, set realistic goals and timelines and then deliver an end product.

Figure 1 *Students presenting their posters to community groups in an open forum during the 'Management Development' project:*

As mentioned, the exercise is multidisciplinary in nature and involves students from two separate Colleges. It also involves collaboration with CKI to incorporate a strong community-relevant dimension to each project. A deeper understanding of the NGO sector enhances students' awareness that altruism and civic responsibility are to be valued and encouraged in both personal and professional spheres. From the NGOs' perspective, the students' evaluations of their organisations often reveals the potential for continued collaboration into the future: "*What the students have revealed is that their particular perspectives, drawn from both geography and engineering, can provide very rich and critical insights that enhance understanding of a wide spectrum of development issues, and which in turn can help NGOs to better project the invaluable work they already do*".

Dr. Brenda Gallagher from NUI Galway's School of Geography and Archaeology has professional experience of development work in Malawi, and remarked that the project has helped the students develop a broader perspective on global development within national and international communities: "*There are many fixed ideas about the nature of NGO activities and often little awareness about the difficult practical and ideological environments which they must navigate. This project has helped to bring the students closer to an understanding of these issues, and to identifying ways they can constructively assist NGOs in their activities*".

3. Professional engineering placements in developing countries

Many engineering courses require students to gain professional work experience through placements with engineering organisations. In April 2009, the College of Engineering and Informatics at NUI Galway initiated a pilot programme with a partner called Alan Kerins Projects to give undergraduate students the opportunity to work in Zambia as part of their academic course. This was expanded in 2011, where another partnership was established with Foundation Nepal allowing students to complete their work placement in a remote region of Nepal. These last for around 16 weeks (8 weeks training and 8 weeks in the field) and the whole process takes a minimum of six months. They are credit-rated with 2 ECTS.

Extract from Table 1 *Summary of 'Engineering for Humanity' professional field placements:*

Module	Programme	Year	Number of students each year	Number of community partners
Engineering for Humanity – professional field placements	BEng Civil Engineering; BEng Environmental Engineering; BSc in Project and Construction Management.	3rd yr	8	2

The project is divided into three phases: completing initial training at university; on placement in Zambia or Nepal, and; completing the final year project on a related topic. Furthermore, several projects have led to a number of postgraduate research projects. Figure 2 shows the model of how these placements relate to different levels of education.

Figure 2 *Model for the 'Engineering for Humanity' projects*.

Students are chosen for this programme based on a competitive interview process. Students receive a conditional offer for a position on a project, provided that they fulfil all the requirements set out. They must complete pre-departure training and preparation and submit a signed pre-departure form (containing information such as contact details, travel itinerary, health insurance, medical examination, immunisations received, pre-departure training, etc). The form was adapted from that used by the School of Nursing & Midwifery at NUI Galway.

There are a number of undergraduate degree programmes in NUI Galway where students work overseas and obtain credits towards their degree. Pre-departure training was developed in collaboration with other university departments. Specific technical training is also given to the selected students. Overall, the pre-departure training sees the students undertake laboratory-based work and research projects, as well as receiving courses on cultural awareness, security, child protection and issues in global development.

Examples of tangible outputs from the projects were:

- Detail design of a water system upgrade for an orphanage.
- Research into the agriculture and industry around in western Zambia, with specific attention to waste products that could be used in stabilised soil blocks.
- Engineering and science workshops.
- Digital survey of land and buildings.

Figure 3 *Repairing a borehole at Kaoma orphanage in Zambia (left) and a 3D model of planned project for the orphanage (right).*

This programme clearly indicates potential areas where ethical, globally aware, civically engaged and socially responsible engineering education can flourish. Benefits of the pilot programme have been highlighted by the author in academic publications (see, for example, Goggins, 2010).

4. Postgraduate module supporting community-engaged research

NUI Galway is the first university in Ireland to offer postgraduate students the opportunity to apply their discipline-specific knowledge and skills to the design, conduct and reporting of a community-engaged research project. Since September 2011, PhD students have the option of working in small teams to address the research needs of voluntary or community organisations as a credit-bearing module in a postgraduate research programme. The module is called 'Engaging with the Community: Research Practice and Reflection' and takes about 200 hours over one year. It is credit-rated with 10 ECTS.

Extract from Table 1 *Summary of 'Engaging with the Community' postgraduate module:*

Module	Programme	Year	Number of students each year	Number of community partners
Engaging with the community: research practice and reflection	Structured PhD in College of Arts, Social Sciences and Celtic Studies; Structured PhD in College of Engineering & Informatics.	MA / MEngSc / MSc / PhD	10	2

This module is one of the outcomes of the 'Community-Engaged Research in Action' (CORA) project, which is a partnership between NUI Galway and COPE (a local community organisation whose work includes supporting homeless people and victims of domestic violence). CORA aims to further enhance sustainable and collaborative research partnerships between the university and community. This module was developed by CORA together with the College of Medicine and Health Sciences, the Centre for Participatory Studies, CKI and the author (on behalf of the College of Engineering and Informatics).

This research initiative builds further on the international reputation NUI Galway enjoys for supporting civic engagement. With the implementation of this module, the university aims to develop PhD students' research skills in an applied, real-world setting to meet community needs. The module aims to give students the opportunity to:

- Enhance their personal effectiveness, capacity for innovation and professional competence thus increasing their employability
- Develop research skills in an applied, real-world setting, in response to an identified research need
- Apply discipline-specific knowledge and skills to a research project
- Work collaboratively with a community partner and/or as part of a research team
- Work with people from other disciplines in solving research problems
- Develop a deeper insight into the impact of socio-economic conditions and public policy on real world issues
- Scrutinise and reflect on social norms and their own role as agents of change.

MEETING HIGHER EDUCATION KEY SUCCESS FACTORS

- **Investment in resources**

  As has been discussed, the university itself has been extremely supportive of Service Learning modules and other community engagement activities. NUI Galway and its leaders place great importance on civic engagement and Service Learning is referenced as a key pillar in the past and current Academic and Strategic Plans. The CKI continue to provide support in maintaining Service Learning programmes including training for staff in best practice and the ongoing needs assessments for new community partners.

  Community engagement experiences have been expanded and embedded across the Civil, Electronic, Mechanical and Biomedical Engineering curricula. Furthermore, a cross-university approach to engage multiple departments has been developed. All students undertaking engineering undergraduate degree programmes in NUI Galway take a Service Learning component during their studies. This greatly supports the integration of the Global Dimension. Around 12 academic staff and a number of support staff are involved in Service Learning modules in the College of Engineering & Informatics. The college continues to allocate the necessary funds to support service learning modules. This includes basic costs related to managing the projects, as well as costs connected with their associated activities.

- **Innovation in education**

  Each Service Learning module is unique and has been designed to embed within the existing curriculum to improve students' learning. Using a model of experiential learning, the purpose behind the programmes is to encourage students towards community engagement by challenging them to develop a self-directed project that applies skills gained so far in their academic preparation.

  The projects offer students a unique learning experience, where creativity, teamwork, communication and real-world problem-solving abilities are recognised and rewarded. In the feedback studies and focus groups, students clearly stated that the real-world output was a motivator to stretch their abilities and to put the fundamental material learned into use. The learning is student-centred, with students taking responsibility of their projects and workload. Both student and community partner feedback highlighted the importance of the student-led approach, with staff and postgraduate students in the university acting in a facilitating role. The findings from these studies can be found in peer-reviewed international publications NUI Galway academic staff (Wallen & Pandit, 2009; Kilmartin, 2010; Byrne & McIlrath, 2011; Goggins, 2012).

- **Commercial potential of research**

  The Service Learning modules give students an opportunity to work on projects in a real-world context with a client, constraints and a real need. Students usually become acutely aware of the budget constraints of their community partner and the impact that will have

on their engineering solutions. Further, the projects give students opportunities to experience a more ethical approach to engineering. Service Learning has its roots in social entrepreneurship, and in most disciplines the project groups are encouraged to remain aware of the commercial potential of the solutions they develop – and in particular the impact that the cost of their solution would have on its 'market potential', particularly in a market which is typically very cost sensitive.

Prototype products developed by students in Mechanical, Biomedical and Electronic Engineering degree programmes receive recognition for their potential impact through national awards and press coverage. Many recommendations from civil engineering projects have been implemented by community partners.

During the 'Engineering for Humanity' programme, some research projects have led to upskilling of the local workforce and increased employment by, for example, setting up a micro-enterprise facility for making stabilised soil blocks in western Zambia (where profits from the enterprise go towards running costs of the local orphanage).

- **Actual or potential contribution to the economy**

  Each year, the 200 engineering students who participate in Service Learning programmes complete well over 10,000 hours of service to the community. The students have established positive links between the university and many community partners. A wide variety of projects have been completed, with most producing a tangible tool or a service that had a significant impact on the quality of life of others in the community – and/or proposed multiple cost saving measures for their community partners. This constitutes a real economic benefit that complements the social contributions.

  Social connections amongst students and community partners inevitably strengthened, which allows for further relationships such as postgraduate research.

- **Differentiation**

  There are a number of factors that place NUI Galway's initiative in engineering education through Service Learning as being unique and valuable. These include:

  - Recognition as 'best practice' internationally (for example through international awards or involvement in projects to embed the model in other countries).
  - Civic engagement and partnership.
  - Engaging new stakeholders in university education.
  - Problem-based learning, but fulfilling real needs.
  - Local, national and international projects (giving students global skills).
  - Academic staff buy-in in terms of time and vision.
  - Academic credit is given to the Service Learning projects.
  - Mandatory requirement of the curriculum for all engineering disciplines.
  - Broad and deep embedding of the Global Dimension across all levels.

CONCLUSION

This chapter provided examples from NUI Galway of how Service Learning can be used to integrate the Global Dimension into academia, from undergraduate programme modules to post-graduate research. The examples have demonstrated both very broad projects (such as the multi-disciplinary projects) and very deep projects (such as the field placements).

These are examples of the use of teaching and learning methods that encourage students to become independent, critical thinkers who are fully engaged with the subject matter. The curricular 'domains' of knowing, acting, and being (Barnett & Coate, 2005) relate to the content, skills acquired by the student, and human development, respectively. Introducing community-based projects improved the curriculum with respect to each of these domains. Firstly, the projects permit the students to obtain a deeper understanding of some aspect of the course. Secondly, students have the opportunity to develop their skills in areas such as research, teamwork and communication. Thirdly, working on community-based real projects can help students to develop through civic engagement, which may also improve their employability and mastery of a discipline.

Community-based projects help to link the information taught in lectures to what is needed in the commercial environment and in local communities. It is heartening to note that the benefits of the project were independently identified by the participating students. Furthermore, knowledge transfer takes place between the academic, students and local community. One of the advantages of this, noted by Trowler and Wareham (2008), is "*claims about a teaching/research nexus having instrumental value in terms of marketing of programmes and courses and institutional reputations*". Using approaches like Service Learning to embed the Global Dimension, therefore, brings immediate benefits for students, academics, local communities, widening participation in engineering, attracting more young people into engineering and for the success of universities themselves. In the longer-term, civic-minded global engineers will be better able to respond to the challenges they will face in their own communities, and in the world at large.

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