

# The Broader Development of the Student Engineer through Industry Based Experiential Learning

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**ABSTRACT:** The global drive for industry-aware and industry-ready engineering graduates, has led to the development and integration of experiential learning through work placements. Industry is looking to recruit graduates with not just the requisite technical engineering skills, but also graduates with inter alia high levels of teamwork and communications skills. This has been recognised by CIT with the integration of work placement in most of its undergraduate programmes. This paper provides an overview of the student placement process in the Department of Civil, Structural and Environmental Engineering at CIT. This paper documents the evolution of the placement process over the past 10 years, and the department's development of online submission and monitoring procedure for students. The findings of a survey of student engineers are presented, following their return to CIT, having recently completed a summer work placement internship. Whilst it is evident that placement will deepen the technical knowledge of the student, a significant finding of this research identifies the many areas that are developed and deepened in the student engineer as a result of the placement. Many students cited increased confidence and a greater focus on their studies once they return to study after the placement.

**KEY WORDS:** Work Placement, Experiential Learning

## 1 INTRODUCTION AND BACKGROUND

The Department of Civil, Structural and Environmental Engineering (DCSEE) set up a five credit Work Placement elective module in September 2007. The aim of the industrial placement is to introduce the learner to structured employment in a relevant work sector and to develop in the learner an understanding of the organisation, its procedures and technology. There is a growing body of knowledge and literature on the impact of work placement on the student and this paper will further contribute [1, 2]. This paper will present the development of the module within the department over the past 13 years, and how the department developed an online management system for the many student submissions. The paper will report on the findings of a student survey from the summer of 2019 cohort of placement students, with some very insightful findings.

The structure of the 'Work Placement Alternative' (WPA) module is also presented, which was required to replace a new 15 credit module due to commence in March 2020. Due to COVID19 restrictions, all but one student were unable to take up their placement positions and thus took the WPA module.

## 2 STRUCTURE OF 5 CREDIT MODULE

### 2.1 Learning Outcomes

The original five credit module first developed by the department in 2007 was offered as an elective, and thus students have taken the module during their summer vacations.

The learning outcomes of this module were:

1. Critically analyse the enterprise, its culture and organisation
2. Communicate in a professional manner within the workplace
3. Demonstrate initiative whilst working alone and in teams

4. Apply knowledge, skills and competencies acquired during the programme of study to the analysis and solution of workplace problems
5. Reflect on and analyse the learning experience resulting from the work placement.

The placement was for a minimum of eight weeks, though many students choose to remain for the full summer period, up to 12 weeks. The student was assigned a work placement mentor by the host organisation. The department requested that the mentor should ideally be a Chartered Engineer. The student was also assigned a member of staff from the department to act as a supervisor.

### 2.2 Assessments

There were three main assessment components for the learner to undertake. Table 1 gives a summary of the assessment breakdown, followed by a brief discussion of each element:

Table 1. Coursework Breakdown (%).

Description	% of Total
Visit by CIT staff to interview student and workplace mentor or other appropriate provisions (week 4)	15
Assessment based on feedback from workplace mentor	25
Report and/or oral presentation on work placement	60

2.2.1 Week 4 interview and preliminary report

For the first four years, the full 15 % was awarded for the interview. After an internal review of departmental staff, it considered that 15% was excessive at such an early stage in the placement. In 2012, the “or other appropriate provisions” was added to this assessment component. From then on, the learner had to submit a “Preliminary Report” (PR) in Week 4. The motivation for this PR was to improve the standard of the draft reports that were submitted at the end of the placement. As the students needed to address each element of the placement in their PR, it ensured the learner was aware of what was required during the second half of the placement and would be encouraged to add to and update the report during the placement. The learner was also expected to maintain a work diary/journal recording and describing briefly the projects or processes on which he/she worked and his/her function. The journal was signed by the mentor and submitted to the CIT supervisor every Friday. The journals were included in the appendix of the main report.

2.2.2 Final Report

There were three components to the “Report and/or oral presentation on work placement”, the report, the presentation and a poster. The learner submitted a draft of the report at the end of the placement. The CIT supervisor gave feedback to the learner and the final report was submitted in September. From 2009 to 2016 the students gave their presentations to the supervising lecturers. Other members of departmental staff along with the Level 8 Year 3 students, who were due to undertake placement the following summer, were also invited. The attendance at these presentations varied from year to year, due to timetabling issues etc.

The value of these presentations and their potential impact was identified as an excellent opportunity for the 1<sup>st</sup> year cohorts to attend. Thus the focus of the presentations was flipped to become peer to peer learning, where 1<sup>st</sup> year students within their 1<sup>st</sup> six weeks at CIT, could now listen to their peers 1 or 2 years ahead of them and see the opportunities that awaited them if they engaged in their studies. So the placement students, whilst also reporting and presenting on their placements, were role models for their peers. This shared experience with the 1<sup>st</sup> years had a very positive influence. The department also served refreshments, to allow time after the presentations for casual and non-formal interaction between the 1<sup>st</sup> years and the more advanced classes.

From September 2017, the students were also asked to prepare a poster of their placement. These posters were placed in the lecture theatres used by the students within the department, thus allowing students to see the range of employers and opportunities that were available to them.

2.2.3 Mentor Feedback

The mentor was given a questionnaire after the placement and asked to give feedback on the performance of the student. The mentor gave a mark out of 10 for 20 categories. One challenge the department faced from this questionnaire was that some mentors would give 10 for every section. The following note was inserted just before the mentor took the survey:

Please note that a mark of  
7 or higher is a First Class Honour

6 is Second Class Honour, Grade 1  
5 is Second Class Honour, Grade 2  
4 is a Pass  
Less than 4 is a fail

This resulted in a broader range of marks.

3 NUMBERS TAKING THE MODULE

Figure 1 shows the number of students taking the module from the summer of 2008 to the summer of 2019. In the academic year 2013/14, twenty students took the work placement module. However, ten of these took the module through Recognised Prior Learning (RPL).

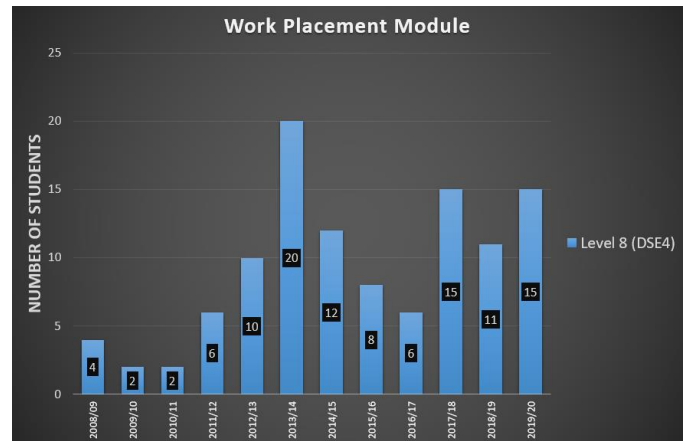


Figure 1. Level 8 students taking the module

For students to be eligible to take the module, the Level 8 Year 3 students must have achieved at least 55 credits. If they achieved less than 55 credits, they could take up the position as work experience but could not take the work placement module. As the students took the module between Year 3 and Year 4, the credits were assessed and recorded in Year 4 of the programme.

Figure 2 shows the Percentage of eligible students taking the module along with the number of students taking the module.

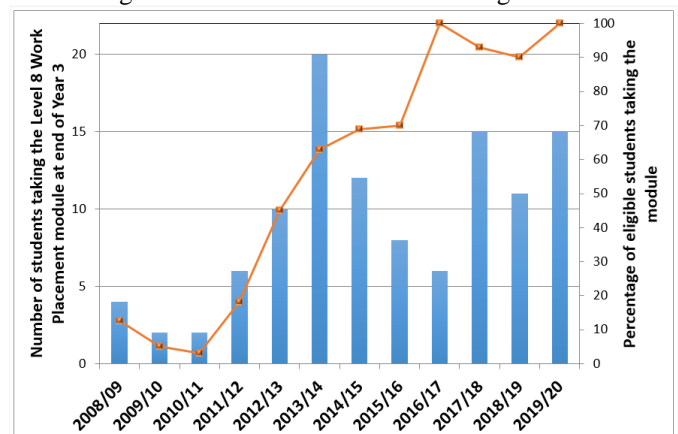


Figure 2. Percentage of eligible students taking the module

In the summer of 2016, all eligible level 8 students were on work placement. At this time, the department had more companies looking for students than students looking for placements. It was decided to develop a Level 7 Work

placement module. The learning outcomes of the Level 7 module were:

1. Describe the enterprise, its culture and organisation.
2. Communicate in a professional manner within the workplace.
3. Work effectively, alone and/or in teams.
4. Apply knowledge, skills and competencies acquired during the programme of study to the analysis and solution of workplace problems.
5. Describe the learning experience resulting from the work placement.

The Level 7 Work Placement module was offered to the following class groups:

- Level 7 Year 2 Civil Engineering (CE2)
- Level 7 Year 2 Environmental Engineering (EE2)
- Level 8 Year 2 Structural Engineering (DSE2)

Similar to the Level 8 module, as the students took the module between Year 2 and Year 3, the credits were assessed and recorded in Year 3 of the programme. Figure 3 shows the total number of students taking the module from the summer of 2008 to the summer of 2019.

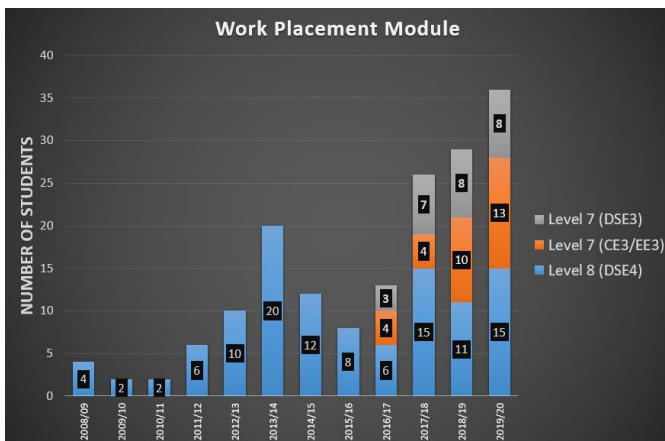


Figure 3. Percentage of eligible students taking the module

#### 4 CHALLENGES – MANAGEMENT OF STUDENT SUBMISSIONS

The major challenge faced by the department was the management of the ever growing number of submissions, due to the increase in WP students. In 2016 the number of submissions was:

- Weekly journals 26 x 8 = 208
- Preliminary reports = 26
- Draft reports = 26
- Presentation = 26
- Poster = 26
- Total = 312

Up to the summer of 2017 all submissions were either e-mailed to the supervising lecturer or a hard copy was posted to the departmental secretary. In 2017 the Department partnered with the Technology Enhanced Learning unit (TEL) within CIT to develop a smarter system for submission management. The TEL set up a Google Drive system where the students uploaded all their submissions to this one location. The system was a big improvement on e-mailing lecturers. All the submissions were

stored in one location. This system proved cumbersome, as it was not easy to identify missing submissions.

In September 2018, CIT migrated to Canvas for its student interface. The TEL assisted the department, in setting up the Canvas module for work placement. This new canvas setup served a number of purposes:

- Issue student announcements.
- Storage of departmental guidance notes to students undertaking the module.
- Storage of students many submissions.
- Hosting of online student conferences to address changes/issues during the placement

The system to upload assessments was extremely user friendly. Figure 4 shows the journal submissions (the student names have been removed from the left hand side). The lecturer can easily see that a file has been uploaded for each student for the first four weeks, or more importantly can easily identify who has not submitted. If a student falls behind in submissions, the lecturer can contact the student to see if there is a problem.

Week 1 Journal ... Out of 10	Week 2 Journal ... Out of 10	Week 3 Journal ... Out of 10	Week 4 Journal ... Out of 10

Figure 4. Canvas submissions

The supervising lecturers were able to set up conferences within Canvas to answer any questions the students had regarding the placements and the submissions. These conferences were recorded and the recordings were available for the students to view throughout the placement.

#### 5 SURVEY OF THE STUDENT EXPERIENCE, SUMMER 2019

A survey of the cohort of students who undertook work placement in the summer of 2019 was conducted. The purpose of this survey was to understand and evaluate the student experience of what they felt they gained from work placement. A total of 36 students took the five credit elective, with 29 responses to the survey. Within these 29, 12 were in placement in consultancy, 10 placed with contractors and 7 students taking work placement with a local authority. Of the 29 students who completed the survey, 14 took the level 7 placement module and 15 took the level 8 module.

The scope of the survey was structured around three key areas:

- the overall student experience and what they considered they achieved from work placement
- the importance of communication methods in the workplace
- the subjects which they felt were most important to them in the workplace.

The survey structure, questions and results for these will be discussed.

5.1 Overall student experience

Overall the students rated their work experience module as having broadened their engineering education as 8.76/10. Students were asked on a scale of one to 10 to rate the following statements with the results presented in Table 2

Table 2. Student experience [3]

Survey statement 1= disagree; 10= strongly agree	Average rating
The work experience module broadened my engineering education	8.76
The module encouraged me to be more engaged with my studies during my remaining years in CIT	8.1
The module is critical to my formation as an engineer	9.0
The module helps me to improve my communication skills	8.86
The work placement experience has increased my confidence	8.59
I now have a better idea of the sector in which I would like to work following graduation	7.76
Did your employer give you an appropriate amount of experience	8.41

Overall students clearly felt that the work placement opportunity broadened their engineering education and encouraged them to become more engaged in their future time at CIT. It is very interesting to note how important the work placement opportunity is to the student's confidence as an engineer.

Students were asked to rate the impact that the placement had on their personal development and how they approached the return to college with once again 10 being very significant. The overall results from the students gave an average number of 7.83 Figure 5 shows the distribution of that opinion.

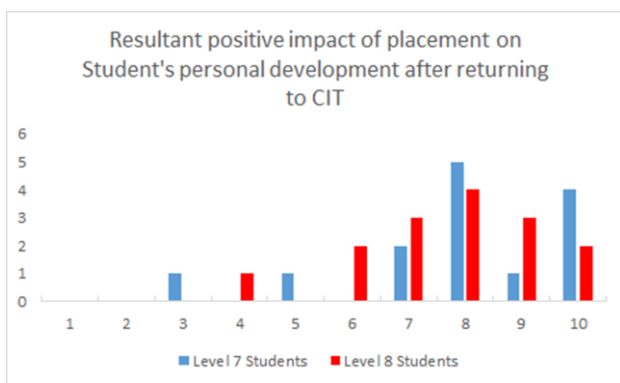


Figure 5. Positive impact of placement [3]

5.2 Importance of communication methods and technical topics/modules

Students were asked to rank the importance of a number of communication methods in order of their importance, for students to successfully undertake work placement experience: 1 = most important 2 = 2nd most important, and so on. The

results to this question are presented in Figure 6 below. This question was asked so that the department could understand which communications methods students perceived as being most important to them. The results of this question will inform future curricula development and design within the Department.

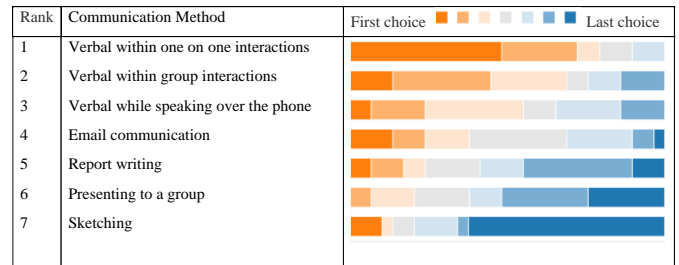


Figure 6. Importance of communication [3]

Students were asked to rank engineering education topics/modules, in order of their importance to preparing the student for work placement experience, with 1 representing the most important, 2 representing the second most important, and so on. Figure 7 below illustrates clearly which subjects students consider most important, with CAD and Health and Safety ranking 1<sup>st</sup> and 2<sup>nd</sup>.

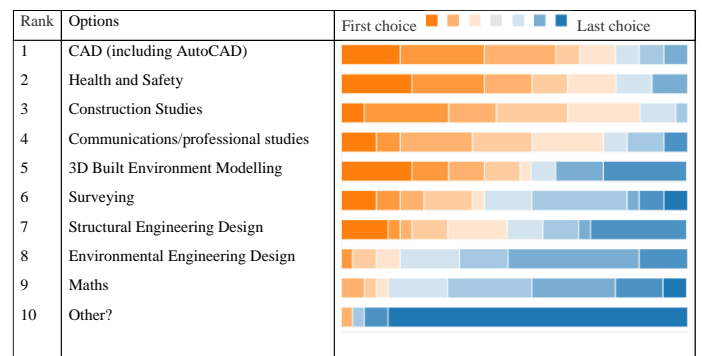


Figure 7. Modules that prepare the student for work placement [3]

5.3 Improvement in Student's abilities after placement

Students were asked to rate on a scale of 1 (no improvement/increase in skill and ability) to 10 (very significant increase in skill and ability), their perceived improvement in skill and ability having completed the 'Work Placement' module. These results are presented in Table 3.

Table 3. Improvement of skills [3]

Student Skills	Improvement in Skills after placement
Verbal communication with individuals	8.07
Verbal communication within groups/teams	7.28
Written communication	7.34
Graphic communication (e.g. sketching, drawing, etc.)	6.9
Self-confidence	8.17
Working independently	8.59
Teamwork	7.97
Technical knowledge	8.31

The survey further focused on the student’s undergraduate education to date and asked them to rate on a scale of 1 (strongly disagree) to 10 (strongly agree), their opinion on a number of statements and whether you they feel adequately equipped to work within the professional environment during their placement. Table 4 shows the results of this survey.

Table 4. Readiness for work placement [3]

Did you consider yourself adequately equipped for the workplace?	Rate
Verbal communication	8.52
Written communication	7.48
Presentation skills	7.28
Health and safety competencies	8.55

The evidence from this question would suggest that students feel adequately equipped for verbal communication but need to further enhance the written and presentation communication skills. The Department has invested considerable effort and curriculum restructuring to incorporate a mandatory health and safety module for all level 7 and level 8 students in either year one or year two of their studies. It is therefore satisfying to the department, that students feel they are ready and competent for health and safety issues that pertain in the workplace – a vital element of any workplace.

Whilst the primary function of an engineering education is to develop engineering knowledge and competence, the broadening of the engineering students’ education to build their confidence and self-esteem is not something that can be easily taught in the classroom. Judging by the feedback from this cohort of students, this broadening of their education and development has been achieved through the work placement module. Students were invited to share what they considered as their key learning outcome at the end of the survey and the following are some quotes from them, which truly demonstrate that broadening and development of the student engineer [3].

*‘More confidence taking on more complicated and larger jobs’*

*‘More confidence in my ability’*

*‘Improved communication skills, and learning to adapt to the workforce’*

*‘Learning to work independently and within a group on a large scale project where a deadline is set.’*

*‘Self-belief in tackling challenges that I’m inexperienced in’*

The students were also asked to reflect on placement and provide one word which summarises their experience. This was compiled into a word cloud in Figure 8, and clearly illustrates that confidence was one of the key elements to work placement, along with knowledge and experience.

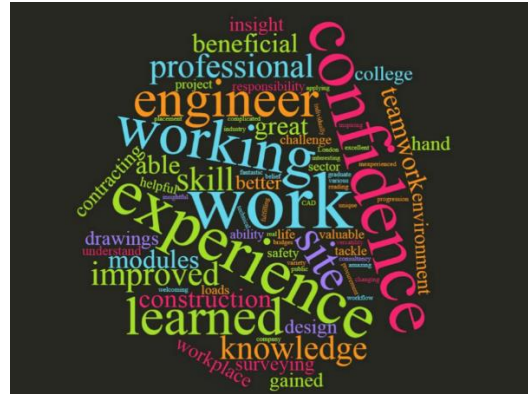


Figure 8 Word cloud generated from student survey data [3]

6 COVID-19 AND WORK PLACEMENT

The department undertook a Programmatic Review in May 2019. It was decided to change the Level 8 Work placement module from a five credit elective module to a fifteen credit mandatory module. The five credit Level 7 Work Placement elective module did not change. The first cohort of Level 8, fifteen credit WP students were due to start their placement in March 2020 [4]. Unfortunately due to Covid-19, 21 of the 22 placements were cancelled. The department developed an “Alternative Work Placement” (AWP) module, which met each of the work placement module learning outcomes, with a focus on Industry 4.0 and lean six-sigma.

Students were encouraged to link in with their original host organisations for both the Industry 4.0 and the six-sigma assignments. Whilst providing the student with input to the assignments, the vital link with the host organisations and possible future work and graduate positions was crucial. It has been the experience of the department, that many WP students are offered graduate positions as they return to CIT for their final year. Thus the WPA was structured such that this link could be developed for the 2020 cohort of students as well.

6.1 Module Elements

The AWP consisted of three different elements, with four different assignments to evaluate the student learning. The main elements of the modules are as follows:

6.1.1 Departmental Lectures and Tutorials

The departmental WP coordinators introduced the AWP and held weekly/bi-weekly online tutorials, to discuss and clarify any assessment issues the students were experiencing. The Department also invited and hosted (online) guest lecturers from the work placement industry partners. These guest lectures gave presentations to the students on the topics of Industry 4.0 and six-sigma.

### 6.1.2 Remote Delivery of Computer Science Module

The Department of Computer Science remotely delivered a module - Emerging Technological Trends COMP8045 [5]. These lectures informed and inspired the students in preparing their Industry 4.0 projects, which were assessed by the Department of Civil, Structural and Environmental Engineering. The full list of lectures are listed in Table 5 below.

Table 5 Emerging Technological Trends COMP8045 [5]

Title of Lecture
Origins of our Digital World
Addressing Societal Challenges through Digitalisation
Blockchain and its applications
Cloud Computing
Cybersecurity threats and challenges
Internet of Things (IoT)
Industry 4.0
Smart Healthcare
Machine Vision
Natural Language Processing and its applications
Deep Convolutional Neural Networks

### 6.1.3 Remote Delivery of Lean Six Sigma Yellow Belt Training Course

The Six Sigma Yellow belt lectures were delivered remotely by an external provider over 6 weeks. All students successfully completed their projects and achieved a Lean Yellow Belt Certificate.

## 6.2 AWP assessments

There were four elements to the AWP assessments:

### 6.2.1 Group Industry 4.0 appraisal (25%)

The students were asked to analyse a particular sector for Industry 4.0, relative to international benchmarks. Working in groups, the students researched and prepared a briefing document on the essence of Industry 4.0 for their sector, and analysed their sector for Industry 4.0 readiness. The students were encouraged to research peer reviewed papers and take on-board the lectures from the module COMP8045 – Emerging Technological Trend

### 6.2.2 Individual Industry 4.0 appraisal (30%)

The students were asked to evaluate their proposed host organisation, with a development plan for implementing Industry 4.0.

This was to include:

- Using their knowledge from the group project, prepare an appraisal framework for their sector, for adapting to Industry 4.0
- Evaluation of their sector using their appraisal framework
- Design an execution plan for the virtual interdisciplinary design or construction team for their host company. This was to include an evaluation of alternative technologies, protocols, method of project managing the team etc.

### 6.2.3 Six Sigma Project (30%)

The students identified a Six Sigma project appropriate to their sector, with guidance from the Trainer.

### 6.2.4 Personal reflection (15%)

The students were asked to prepare a detailed reflection of their adaption to this type of remote academic teaching, learning and assessment. The three reflective pieces required were entitled:

1. 'My performance within the team dynamic'
2. 'The influence of attitude'
3. 'Me, myself and I'

## 7 CONCLUSIONS AND RECOMMENDATIONS

Experimental learning at the Department of Civil, Structural and Environmental Engineering displays the very clear evidence of a positive impact that work placement has on the student engineer. This paper tracks the evolution of the work placement and experiential learning within the department over the past 13 years, and the development of the work placement alternative during the COVID-19 pandemic.

Results from a survey of 29 students points very much to the positive and broadening personal experience of the student engineer due to completing work placement. Students clearly recognise the additional learning that is achieved in the engineering subjects during their experiential learning; however, it is the building on and further developing of their confidence and communication skills that is most apparent from the survey.

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