

Preparing future (chemical) engineers through work-based experiences

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Abstract: Employability of graduate engineers is a priority for universities. Engineering programmes across the UK are integrating employability education in their curriculum, in an effort to prepare employable engineers, aware of their technical and transferable skills and how to use them to drive change. At the Department of Chemical & Biological Engineering (CBE) at the University of Sheffield, we have graduate employability at the heart of our Curriculum, connecting practical design, core knowledge, and enabling science modules, with practical experiences and employment outcomes. CBE has put emphasis on critical thinking, problem solving, professionalism, ethics and sustainability in an effort to teach our student engineers how to apply their education for the benefit of the society. Our Curriculum offers an array of opportunities for problem-based and project-based learning, and also we actively encourage work-based learning. This paper presents the impact of embedded opportunities for work-based placements, and shows how our students achieve work-based learning through schemes such as summer research placements - available to all students, the Year-in-Industry (YiI) placements for those on a YiI programme, and the Research Projects for those on an MEng programme. Graduate outcomes show that students who take on such opportunities develop a better understanding of their employability, having acquired an experience-based skillset and having seen engineers in professional settings. Especially for the research placements and the MEng Research Projects, the very current research themes of CBE ensure exposure of students to various areas that enhance the preparedness of our graduates for the Fourth Industrial Revolution.

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1. INTRODUCTION

1.1. Introducing the concept of work-based learning

The notion of acquiring work experience while at university in order to improve graduate outcomes is not new, having been in discussion and application over the past 30 years (Helyer and Lee, 2014; Little and Brennan, 1996; Little and ESECT, 2004; Dalrymple et al., 2021). Relevant research has shown that both educational institutions and employers are fond of internships and placements of various lengths, in order to have students expose themselves to real working environments and get relevant experience before their graduation (MurtazinShvets and Piho, 2020). Educational institutions see this as a way to help students enhance and develop their employability outside academic achievements and understand their career prospects. Employers see that as an opportunity to “trial” students before possibly offering them a place in their graduate scheme or entry level roles, or as a reassurance that if a prospective applicant has some work-based experience, they will overall perform better, as they will have experienced a working environment

before and have developed well-sought-after transferable skills (Helyer and Lee, 2014). Work-based learning can be simultaneously experienced as learning for work, learning through work, and learning at work, preparing graduates for jobs through hands-on experience and application of some of the theoretical background they have gained through their courses (Little and Brennan, 1996). Work-based learning needs to contain the following features: responsibility of the learner towards a specific project, performance- or task-related learning, problem-based learning, teamwork or collaboration elements, performance enhancement, and elements of innovation (including management of change) (Little and Brennan, 1996). One could say that work-based learning is a form of active learning, as it puts students in the centre of the learning process through meaningful activities and critical analysis of what they are doing (Hernández-de-Menéndez et al., 2019).

In an era where the need of certain graduate skills is fast evolving due to global events such as the covid-19 pandemic, or the diversity in sectors, such as inclusion of social science or social sustainability in engineering, or digitalisation, it is important for graduates to understand and equip themselves with skillsets that can grant them roles and careers of the future (Burns and Chisholm, 2003; Alvarez-Aros and Bernal-Torres, 2021; BrooKaynak and Sait, 2022). This can be done through the Curriculum, if module leaders adjust their content to help graduates develop such skillsets, but more importantly, it can be done through work-based learning. Through work-based learning undergraduates can immerse themselves in first-hand experiences that they can expect when formally employed in graduate roles. Through these experiences they can observe seasoned employees, apply knowledge they have gathered from their education, learn about the working environment, and reflect on their standing and developmental needs as prospective employees at particular sectors.

1.2. Work-based learning opportunities at the Department of Chemical and Biological Engineering

Many educational institutions, at least in the UK, are nowadays offering various opportunities for work-based learning to their students (Basit et al., 2016; Pavlaku, 2016). These opportunities could be an organised part of offered courses (e.g. Yil placement during a programme of study), or as optional opportunities throughout the studies and external to the curriculum (e.g. on- or off-campus work placements, research experience, voluntary experience). The Department of Chemical and Biological Engineering (CBE) at the University of Sheffield is offering plenty of opportunities for students to engage with work-based learning. Maybe the most important opportunity is the Yil scheme, where students -if enrolled in courses which support the scheme- get to spend a year in a professional working setting, in a role relevant to their degrees, carrying real responsibility that prepares them for working life after university and maximising their employability (Lenihan et al., 2020; University of Sheffield, 2022). Over 200 students from the Faculty of Engineering in the University of Sheffield attend a Yil (or placement year, or sandwich year) every year, with about 20% of them being from the CBE. Given the role and sector diversity chemical engineering is offering, students have a wide range of companies and roles to choose from, with some examples listed in Table 1.

Besides a Yil placement that takes place at the end of second or third year, the University of Sheffield offers the opportunity for students to take on summer-long placements, exploring the idea of research. Through the popular (and competitive) summer undergraduate research schemes, CBE students have the opportunity to work on topics of interest alongside academics, possibly in collaboration with industries that academics have consulting or other work liaisons with, without the need to interrupt their studies as they would need to do for longer placements. These schemes are focused around research, allowing students to explore a subject of their choice

in depth and maybe consider research as a possible career pathway after their BEng studies, or before they engage more thoroughly with it through an MEng research project. CBE students who choose to do a summer research placement can be working on topics relevant to available academic research interests (Department of Chemical & Biological Engineering, 2021; Department of Chemical & Biological Engineering, 2022).

Examples of organisations where UG students from CBE have found Yil placements		
<ul style="list-style-type: none"> • Airproducts • AstraZeneca • British American Tobacco • Cargill • Caterpillar • Cummins • Eastman Chemical Company 	<ul style="list-style-type: none"> • EDF Energy • Egger • Exxon - Mobil • Hydraclear Process Water • Invista • Kimberly Clark • Mondelez International • Morrisons 	<ul style="list-style-type: none"> • Mott MacDonald • PepsiCo • Pfizer • RWE • Sellafield • Siemens Energy • Smurfit Kappa • Syngenta • Unilever

Table 1: Examples of organisations where CBE UG students have found Yil placements

For those students who are not necessarily drawn to research, the University is offering other placement schemes, known as 100-hour placements, which are usually focusing on areas related to market research, social media strategy, event coordination, communications, or project management.

Students who are enrolled in an MEng course also have the opportunity to build on their work-based experiences through their research project. They can experience work-based learning around research and develop academic skills but also well-sought after transferable skills such as communication, through the deliverables of the research project. In CBE, several academics foster industrial collaborations, and on several occasions MEng research projects are influenced by them. On such occasions, work-based learning is even further explored, with students communicating their findings to academic and industrial stakeholders, in similar ways that they would have to do if they were employed in consultancies. In all cases of work-based learning (year-long placements, summer placements or MEng research projects) students are called to disseminate their findings and reflect on their learning (Table 2).

Work-based experience	Experience showcase / Assessment
Year in Industry (Yil) placement	Poster/presentation, report on outcomes, reflection on skills development
Summer research placement	Poster/presentation, reflection on experience
MEng research project	Tutorials on skills development, oral/poster presentation, report

Table 2: Assessment methods for work-based learning opportunities.

In CBE, students are introduced to the concept of work-based learning from their early days in their degrees, via the carefully re-designed curriculum (Zandi et al., 2017). This is done in order to make sure that by the time they graduate, students are aware of the numerous options that can lead to successful careers in several possible directions. Aiming to validate and accommodate as many approaches as possible, CBE introduced the “Skills for Employability” module in the Curriculum. This module is designed to introduce students to the concept of employability and

professional skills, help students build awareness and enhance their employability through tutorials that build on skills development they undergo during their studies and other experiences.

This practice paper examines the academic progress and graduate outcomes, where available, of current and former CBE students who engaged in work-based learning opportunities. The aim of this ongoing project is to identify whether work-based experiences lead to positive impact in the development of technical and non-technical skills, preparing future graduates for real-life work environments.

2. METHODOLOGY

2.1. Observations regarding the impact of a Year-in-Industry (YiI) placement

The impact of YiI placements was measured on this occasion through Graduate Outcomes data for graduates exiting the university in 2017/2018, 2018/2019, and 2019/2020/2021 (combined results due to the pandemic). Data shown herein were extracted from the Higher Education Statistics Agency (HESA) survey on Graduate Outcomes, filtered for the Department of Chemical & Biological Engineering at the University of Sheffield. CBE offers four MEng courses in chemical engineering with different focuses and one BEng in chemical engineering, and it also offers the same five courses with the option of a YiI placement.

The areas of the survey relevant to this work were the following: Employment as main activity or unemployment, Mode of employment (full time, part time), Contract agreement (permanent or not), Skill level required for the role, Salary insights.

Data were extracted, normalised based on the number of responses, and are presented in percentages. Where necessary, a t-test as conducted to indicate significant differences across compared values.

2.2. Observations regarding the impact of a summer placements and MEng research projects

The impact of summer placements was measured through graduate outcomes where available, and also through academic performance. Individuals who were awarded a summer placement in the last four years (2017/2018, 2018/2019, 2019/2020, 2020/2021) were identified and their academic performance was compared to the average for the cohort on. The impact of research projects was measured through the Graduate Outcomes survey available through the Higher Education Statistics Agency, filtered for the MEng and BEng courses CBE is offering. Where necessary, a t-test as conducted to indicate significant differences across compared values.

3. RESULTS

3.1. Observations regarding the impact of a Year-in-Industry placement

Looking at the filtered HESA survey graduate outcomes over the past three years and focusing on Employment or Unemployment of graduates who were enrolled on a course with a YiI placement and graduates on standard courses (240 responses), we can see that there is a clear difference across the two sets (Figure 1).

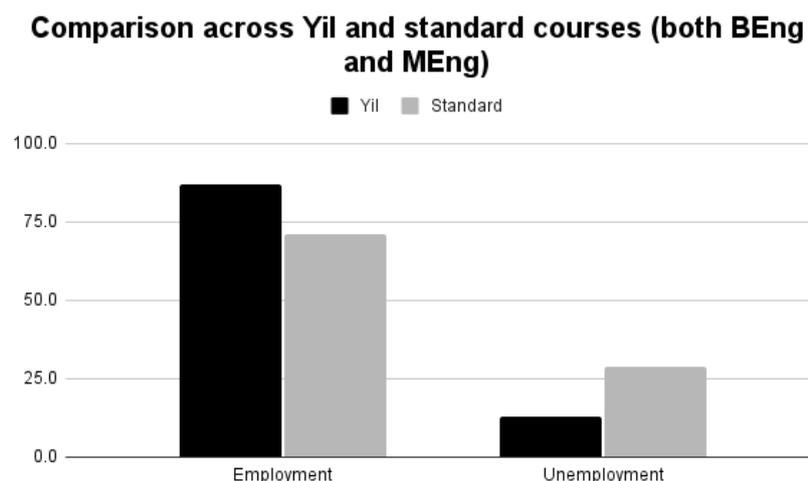


Figure 1: Comparison of graduate outcomes (employment) for students with Yil experience and students on standard courses.

Graduates who had the Yil placement experience seem to have a much higher percentage of employment, 87% compared to 70%, and comparative lower (almost half) percentage of unemployment compared to those who did not have a year-long placement experience.

Looking deeper into job role details (mode of employment, contract, skills level) for those in Employment, there is no commendable difference across the cohorts of those who did a year-long placement and those who did not (Table 3). Regarding salary insights, based on the available data and the relevant salary brackets (£25,000-29,999 p.a. and £30,000-35,000 p.a.), results show that CBE graduates with Yil experience have salaries on average one bracket higher compared to those without Yil experience.

Factor / Cohort	Yil (both BEng and MEng, 6 courses)	Standard (BEng and MEng, 7 courses)
Full time role (%)	91.4	96.2
Permanent contract (%)	72.3	62.1
High-skilled role (%)	87.2	86.4
Salary insights (thousand £ p.a.)	31.0	26.3

Table 3: Comparison of graduate outcomes for students with Yil experience and students on standard courses.

3.2. Observations regarding the impact of a summer placements and MEng research projects

Looking at the filtered HESA survey graduate outcomes over the past three years and focusing on Employment or Unemployment of graduates who were enrolled on a course with a Yil placement and graduates on standard courses (255 responses), we can again see that there is a clear difference across the two sets (Figure 2).

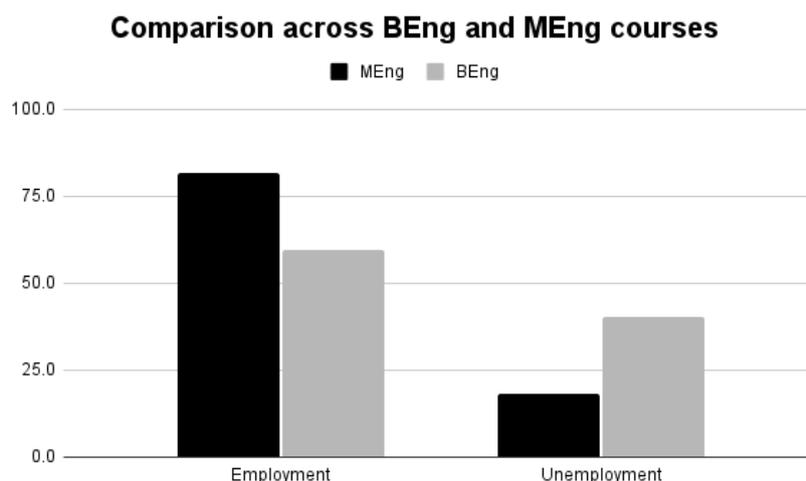


Figure 2: Comparison of graduate outcomes (employment) for students on MEng and BEng courses.

Graduates who completed a MEng course (including a year-long research project) seem to have a much higher percentage of employment, 81% compared to 60%, and much lower (almost half again) percentage of unemployment compared to those who completed a BEng course.

Looking deeper into job role details (mode of employment, contract, skills level) for those in Employment, there is again no commendable difference across the cohorts of those who engaged with a year-long research project and those who did not (Table 4). Regarding salary insights, based on the available data results show that CBE graduates of BEng and MEng courses earn average salaries in the same salary range, £25,000 – 29,999 p.a.

Factor / Cohort	MEng (11 courses)	BEng (2 courses)
Full time role (%)	97.0	93.5
Permanent contract (%)	65.4	63.0
High-skilled role (%)	87.2	84.8
Salary insights (thousand £ p.a.)	28.9	26.9

Table 4: Comparison of graduate outcomes for students on MEng and BEng courses.

Regarding summer (research) placements, in order to investigate their impact on students, we examined the academic performance of students completed a placement for the years after the placement, on a personal and on a cohort level. Results show that out of the 39 examined cases, 54% improved their academic performance in the following year(s) after the placement, and almost 80% of students achieved an average mark above the year average. In 46% of cases, students showed a lower performance compared to previous years, and only in 20% of cases the academic scores for students with placement experience were lower to the year average (Table 5). It is interesting to point out that out of the 18 cases where performance showed to decrease, 12 of them still maintained average within the 1st degree classification. It is also interesting to point out that in 12 of the examined cases students showed an incremental

improvement during their performance, where after their placement they managed to jump from average mark below 1st to average mark within the 1st classification.

	Placement students (#39)	%
Performance improvement (self)	21	53.8
Performance drop (self)	18	46.2
Performance higher than year average	31	79.5
Performance lower than year average	8	20.5
Graduated / in full employment	34/31	91

Table 5: The effect of summer placements on academic performance of students who engaged with them.

4. DISCUSSION – CONCLUSIONS

Work-based learning is the best way to prepare students for the working environment while helping them develop necessary skills. In that direction, CBE is offering several opportunities for students to engage with work-based learning, either by “tasters” such as summer research placements, or by more long-term experiences such as Yil placements or research projects.

Our observations show that work-based learning experiences offered at CBE generally help students who engage with them to improve not only their academic performance, but also achieve better graduate outcomes compared to those who do not pursue such experiences. These observations are in line with findings from (Little and ESECT 2004), who showed, through a review of relevant empirical work, that graduates with some work-based experience are more likely to jump from university directly to professional settings after graduation. In addition, (Brooks and Youngson, 2016) and (YungLam and Yu, 2015) showed that year-long placement students show increased academic achievements, a fact that supports our observations on summer placement students.

These observations are indicative of the benefits work-based experiences offer. In order to gain a better understanding on how exactly students benefit from work-based experiences, it would be necessary to collect data on student perspectives during and after embarking on a work-based experience, as well as collecting data from line managers of these experiences on their perspective of student development.

CBE offers an inclusive, hands-on approach on student employability, putting students on the driver’s seat. Through the “Skills for Employability” module students get introduced to the importance of employability and how to improve it from the early days of their degree, and through a scaffold structure they become aware of the available opportunities to gain work-based experience while at university, how to pursue them, and how to showcase their experience.

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