Opportunities for the Development of Professional Skills for Undergraduate Civil and Environmental Engineers

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Abstract

Employability and skills development are contemporary issues in higher education. For vocational-professional disciplines such as engineering, the signature pedagogy directs teaching and learning towards acquiring scientific knowledge. Engineering employers have called for graduates to be more work-ready and to be trained in team-working, communication and other professional skills. These skills can be developed and assessed within curricular, co-curricular and extra-curricular settings. We consider how a sample of undergraduate civil engineers (*N=58*) perceive the contribution of the above activities on the development of six professional skills (Problem-solving; Planning; Leadership; Team-working; Self-confidence; Resilience). Embedding these skills within curricular activities offers the greatest potential for helping all students improve their employment prospects. Finally, we make suggestions for improving the deployment of professional skills in our four undergraduate programmes, and in higher education institutions in general.

Keywords: Employability; Professional Skills; Civil Engineers; Environmental Engineers; Curricular, Co-Curricular, Extra-Curricular

1. Introduction

A plethora of UK publications over half a century (Committee on Higher Education, 1963; University Grants Committee, 1964; Dearing, 1997; Wilson, 2012; Confederation of British Industry, 2017; CBI, 2019) have called for graduates to have acquired a range of employability skills during their studies. Employability, as distinct from a measure of graduate employment (securing a job), is considered to include students' knowledge, personal attributes and skills that will help them secure employment and engage in continued learning to support career development (Knight & Yorke, 2003; Pegg et al, 2012).

Since the publication of the Dearing (1997) report there has been a growth in employers' involvement in university curricula (e.g. via industrial advisory boards). This is particularly prevalent in vocational-professional disciplines such as civil and environmental engineering, whereby the accreditation body, the Joint Board of Moderators (JBM, 2021, p.21) 'recommends that higher education institutions (HEIs) maintain strong, viable and visible links with the civil engineering profession'. Employers now look to universities to provide work-ready graduates with a range of professional skills including 'time management, team working and problem-solving' (Hewitt, 2020 p.28). Nonetheless, employers continue to identify shortcomings in the abilities of graduates. Succi and Canovi (2020) refer to a three decade 'blame-game' between employer groups and higher education in regard to who is responsible for graduate employability. As an example, a recent survey of international employers (Quacquarelli Symonds Ltd. 2020) found issues with graduates' problem solving, communication, and resilience skills. Robinson (2017, p.55) argued, however, that 'conventional academic programs are not designed to develop [skills]'. Indeed, Barnett (1992, p.160) grappled with this dilemma: 'to what extent can this distinction between general intellectual skills and general vocational skills, be sustained?' It is perhaps an indictment to the pedagogical fads and fashions in HEIs that transferable skills have morphed to become 'transversal' skills development (Larraz, Vazquez & Liesa, 2017; Oleškevičienė et al, 2019) and whilst this may be a matter of semantics it does suggest we have come full circle in regards to Barnett's question. Nonetheless, despite the ubiquitous nature of employability in HEI's, critics (Arnowitz, 2000, Savin-Baden, 2008; Duderstadt, 2010, Collini, 2012) argue that higher education should not succumb to employers demands for training work-ready graduates. In the USA, Arum and Roksa (2011) argued that students had become distracted from scholarly activities due to socialising and extra-curricular activities, and that they have become 'Academically Adrift'.

Despite such criticism, an employability agenda is now pervasive within HEIs (Long, Hubble & Loft, (2021; Dalrymple et al, 2021); in the UK's Quality Assurance Agency for Higher Education (QAA, 2019) - *Focus on Graduate Skills 2018-19*; Advance HE (Neves,2019a) - *The Hard Facts of Soft Skills*; (Universities Scotland, 2021) -*Knowledge+* initiative. Moreover, QAA Scotland (2020); recommended that employability should be a fundamental part of curriculum design. Nonetheless, 'it appears that there is more work to do across the sector to help students see how their course and wider interactions are developing a wide range of skills beyond their core academic knowledge' (Neves, 2020, p.34). Given the vocational-professional nature of engineering education, this is particularly pertinent (Wood, 2020). Nevertheless, there remains a fundamental tension in HEIs as to what skills should be developed (Caeiro-Rodriguez et al,2021) and whether they should be embedded into the core curriculum or be 'bolted-on' through specific modules, and/or subcontracted to university careers services (Bradley, Quigley & Bailey, 2021). Moreover, the terminology of so called 'hard skills' and 'soft skills' within, and to contextualise a discipline (particularly engineering), is a contentious one (Matthew and Pritchard, 2009; Berdanier, 2022). As Dalrymple et al, 2021 (p.24) have noted 'there is a clear concern with unpacking the well-worn and increasingly contested distinction between 'hard' and 'soft' employability skills'. Furthermore, Beagon (2021) noted the plethora of terms used to describe the skills required by engineering graduates (e.g. graduate attributes, soft skills and professional skills) and concluded that there was a 'lack of consistency in terminology and interpretation conceptually, yet are often used interchangeably in the literature' (p.21). For our research, we have adopted the term 'professional skills' and contend that these are 'knowing how' skills that support the 'knowing that' (Ryle, 1946) in the curricular, co-curricular and extra-curricular experience of our students.

This article presents the results of an online survey distributed to undergraduate students (years 3-5) enrolled within the Department of Civil and Environmental Engineering (henceforth referred to as the 'department') at a university in the UK. The original purpose of the study was to evaluate our students' perception of the legacy gain (vis-à-vis their skills acquisition) after attending a bespoke Outward

Bound (Outward Bound International, 2020) course during their second-year studies - thus the exclusion of first- and second-year students from the study. The Outward Bound Trust (2017) seek to improve a participant's social and emotional skills, with a focus on the development of six skills (Problem-solving; Planning; Leadership; Team-working; Self-confidence; Resilience). These skills typically feature in the candidate requirements in graduate engineering job adverts. A decision was taken to expand the remit of the research to include a wider portfolio of curricular, co-curricular and extra-curricular activities where our students believed they had deployed the six professional skills competencies.

We concur with Stump, Husman and Corby (2014, p. 370) that an 'examination of students' beliefs about themselves, or self-theories, may provide important insight into their behaviour'. Indeed Dalrymple et al, 2021 (p.17) found a 'growing recognition of the validity of such self-report measures' in their review of employability literature. They concluded that this does perhaps further reflect 'the increasing valorising of students' views and agency in quantifying outcomes and assessing the worth of the employability interventions they have experienced'. The research findings will be used to inform the department's annual evaluation of our two undergraduate programmes. The four programmes are (1) BEng (Hons) Civil Engineering; (2) MEng Civil Engineering; (3) BEng (Hons) Civil & Environmental Engineering; and (4) MEng Civil & Environmental Engineering In Scotland, the MEng programmes are of five-year duration. In the later years of study, the Civil & Environmental Engineering programme places greater emphasis on the main aspects of environmental engineering, such as water and waste treatment and contaminated land remediation.

In section 2 we draw on employability research from engineering, a discipline with a strong vocational-professional heritage, albeit not without a tension in incorporating skills within the engineering curriculum. This section is followed by a detailed explanation of the curricular, co-curricular and extra-curricular activities examined in our survey. The research methodology and details of our survey are examined in section 4. In section 5 we examine and discuss the quantitative data. We present how students perceive these activities and discuss ways to maximise the benefit. In final discussion and conclusions sections, we consider how the results could inform our civil and environmental engineering programmes.

2. Engineering Knowledge & Skills

Recruitment into, and transition through, an undergraduate engineering course requires students to be adept in analysis and is suited to students who have a strong interest in science (Dias, 2019). Despite the necessity of theoretical knowledge, practising engineers require more than a competence in mathematics, physics and equation solving (Ridley, 2017; Vesikivi et al, 2018; Engineering Professors Council, 2019; Kamp, 2020; Daley & Baruah, 2020). Indeed, engineering practice is largely 'practical and empirical' (Dias, 2019, p.98) and 'requires a combination of theoretical knowledge and its practical application, coupled with many other skills' (Uff, 2016, p.8). These tensions came to the fore nearly two decades ago in a report entitled *Mathematics in the University Education of Engineers* (Kent & Noss, 2003). The authors provided pedagogical guidance that has the potential for creating a virtuous symbiosis of the hard and soft skills required by graduate engineers*:* 'we are much attracted by the concept of mathematics being 'pulled' rather than 'pushed' into the engineering context. It would be a natural consequence of pursuing a studio-based, design-led, approach' (p.6).

Over the piece there have been improvements in some quarters in forging this virtuous symbiosis, e.g. Conceiving — Designing — Implementing — Operating (CDIO-Crawley, et al, 2014). CDIO pedagogy creates the 'pull' through teaching for real-world engineering situations through incorporating professional engineering skills with engineering disciplinary knowledge. CDIO was borne out of 'an implicit criticism of current engineering education for prioritizing the teaching of theory, including mathematics, science, and technical disciplines, while not placing enough emphasis on laying the foundation for practice, which emphasizes skills such as design, teamwork, and communications' (Crawley, et al, 2014, p.3).

Nonetheless, the adoption of CDIO in UK HEIs is not widespread and the Institution of Engineering & Technology (2019, p.16) has found that engineering employers have problems 'with candidates who have academic knowledge but lack workplace skills'. The Institution of Civil Engineers (ICE, 2018) drilled down on this issue and reported that soft skills, including judgement and decision making, time management, and communication 'emerged as significantly more important in the workplace than many of the technical skills which dominate the curricula of undergraduate courses' (p.28).The ICE recommend that academia and employers should ensure that an:

> Awareness of the importance of soft skills needs to be inculcated early in their education, and appropriate up skilling provided early in their careers (p.30).

There has been a growth in the adoption of the CDIO approach within HEIs across the globe and this has been encouraged by reports (Royal Academy of Engineering, 2012; Hall et al, 2020) calling for engineering students to be exposed to authentic problem/project-based learning scenarios. Indeed, 'authentic assessment should be considered as a valuable vehicle through which to enhance students' employability and pre-professional self-identity' (Dalrymple et al, 2021, p.76).These learning spaces reflect Donald Schon's (1987) call for 'reflective practicum' within the professional schools whereby students are introduced to the 'swampy lowland, [with] messy, confusing problems [that] defy technical solution' (p.3). Schon's criticism of an engineering curriculum dominated by engineering science, over the teaching of design, are reflected in the CDIO approach. These pedagogies, whether CDIO, reflective practicums, or problem/project-based learning, seek to inculcate in students the habits of mind, and, ways of thinking, that are consistent with professional engineers (Lucas, Hanson & Claxton, 2014; Goldberg and Somerville 2014; Kamp, 2016). As Anderson (2019, p.43) argues, 'engineers need hard skills, but great engineers use both hard and soft skills'. In the UK, the New Model Institute for Technology and Engineering (NMITE) (Hitt et al, 2020) and The Dyson Institute of Engineering & Technology (2021) reflect progressive, albeit, limited interventions, to synthesise the technical skills with those of personal and professional development of engineering students. Nonetheless, as Picard et al (2021, p.15) have observed, 'projects are increasingly important, but it may not always be possible to change whole curricula to organise them around projects, following PBL or CDIO approaches'. Nonetheless, there is empirical evidence (Leslie, Gorman & Junaid, 2021) demonstrating that CDIO pedagogy facilitates an effective learning framework for embedding professional skills within engineering programmes.

With regards to the curriculum for undergraduate civil and environmental engineers, the body responsible for accrediting programmes (under licence from the Engineering Council), the Joint Board of Moderators (JBM, 2021, p.4), recommend that students are exposed to 'practical, applied and authentic design exercises' within a 'learning environment which facilitates collaboration, creative thinking and ingenuity'. In relation to professional skills, the JBM expect universities to provide evidence that their students are able to:

- Demonstrate team working skills and awareness of inclusive behaviours (p.8);
- Demonstrate creative skills through design projects and other activities (p.8); and

- Communicate knowledgeably and clearly (p.18).

A number of commentators have argued that these and other skills are best nurtured through closer industry-academia collaboration (Finniston, 1980; Edward and Middleton 2001; Royal Academy of Engineering 2007; Engineering Professors Council, 2019; Construction Leadership Forum, 2021). As such, it is recommended that universities assist their students to develop their soft skills through participation in work experience, industrial placement, and mentoring by industrial practitioners (Colman & Willmot, 2016; Rich, 2018; Byrne, 2020).

3. Curricular, co-curricular and extra-curricular activities included in this study

Students at the University undertake a large number of activities/assignments offered within their degree programme that aim to assess their understanding and knowledge on technical aspects of the profession. These activities also support the development of professional skills. In this study we focus on six skills: team-working, leadership, planning (including time-management), problem-solving, self-confidence and resilience. We examine how students associate each of these six skills with a range of development activities: curricular (credit bearing, compulsory activities within the degree programme), co-curricular (non-credit bearing, optional activities offered within the degree programme) and extra-curricular (non-credit bearing, student defined, outside the degree programme). More specifically, the following activities were considered.

Curricular Activities (C)

- C1: Individual programme activities. Such activities include for example, individual assignments and studying on specific courses. These could be in the form of lab reports, design projects, research dissertations studying books/journal papers and reporting on these, online multiple-choice quizzes and formal exams. These activities usually have set submission deadlines (e.g. two hours for formal exams up to two weeks or more for lab reports and design projects). Such activities enhance planning (time-management), resilience (work ethic), problem solving and self-confidence.
- C2: Group programme activities. These are designed to assess students' knowledge on specific subject areas and are the result of group work. As such, the requirements on time and effort are higher compared to individual university activities. Group activities include the preparation and submission of detailed lab reports, larger and more complicated design projects, investigation and reporting on specific civil engineering project case studies. These activities have a set submission deadline and students have at least three weeks to complete. They can relate to all six skills taken into account in this study.
- C3: Programme Outward Bound course. All second-year students in the undergraduate degree programme spend 2.5 days at the Outward Bound Trust's centre near Fort William (Scotland) where they participate in a number of outdoor activities such as canoeing, abseiling, raft building and team-building games. The course relates to all six skills in this study. Its aim is to: encourage students to discover their limits (self-confidence), face some of their fears (self-confidence, resilience), trust and work together with their peers to overcome challenges (leadership, time-management, team-working), learn to respect

others and the environment (team-working) and get to know each other (build their social networks, supporting mechanisms within the University).

Co-curricular Activities (Co)

- Co1: Placement/work with a civil/environmental engineering employer. A small number of undergraduate students spend between 8 and 15 weeks during the summer working within the civil and environmental engineering sector. Whilst these jobs are not credit bearing, in some cases such placements result in a part-time job with that employer that extends beyond summer and can lead to a permanent full-time job after graduation. Such placements offer, other than just employment, the opportunity to develop professional skills early in the students' professional training.
- Co2: Attending Constructionarium. Constructionarium (2021) is a voluntary experiential learning initiative and hands-on five-day construction camp where students employ their university theoretical knowledge through design and construction practice. Students (circa 25 each year from across all years of the programmes) have an opportunity to utilise their motor skills through physical work constructing scaled versions of prestigious civil engineering projects, and, to road-test their technical knowledge with 'less tangible skills of organisation, problem solving, people management and team working' (Ahearn, 2016 p.131). The event is hosted and sponsored by a construction company.
- Co3: Attending professional institution events. The students are encouraged to become members of one of the professional institutions aligned to their studies [typically the Institution of Civil Engineers (ICE) and/or the Institution of Structural Engineers (IStructE)], and to attend (voluntarily) institutions' CPD meetings / webinars in order to facilitate networking (Hipkiss, 2006) and to develop relationship competences (Platts and Tomasevic, 2006) through associating with graduate and professional engineers, as well as to gain technical knowledge.
- Co4: Attending Civil Engineering 4 Real (CE4R). Civil Engineering 4 Real (CE4R) are problem-based learning (PBL) evening workshops of two-hour duration organised by the CEE Department and facilitated by practicing engineers, where student attendance is voluntary (Murray, Hendry & McQuade, 2020). Students use authentic documentation and collaborate in peer learning group work to solve industrial problems. Each group (4-5 students) is assembled from students across the programme (years 1-5) who have different prior learning and industrial exposure. Whilst the more senior students are encouraged to mentor junior students the leadership role during each workshop can be considered task dependent, fluid and emergent and dependent on the composition of the group.

Extra- curricular Activities (EC)

- EC1: Working for a non-engineering employer or volunteering with a charity.
- EC2: Caring for a family member or friend.
- EC3: Member of a group such as the Scouts, sports or music groups.

4. Methodology and online survey

We designed an online survey to collect information on how department students perceive the contribution of the above activities on the development of the six skills presented earlier. The online survey was run via the University's licence to the Qualtrics platform, which enables compliance to the General Data Protection Regulation (Qualtrics, 2020). The total time to complete the questionnaire was estimated by Qualtrics to be about 7 minutes. As such we were reasonably confident that students would not experience boredom completing the questionnaire or engage in 'straight-lining' by giving the same response to each question (Leddy-Owen, 2016).

The order of the questions within the online survey was arranged so that respondents had to consider their competence of one skill at a time, proceeded directly by a question seeking to ascertain where students believed they had developed this skill, before moving onto the next skill and repeating this process. We considered that this approach would help reduce the respondents' cognitive load in completing the questionnaire and provide the most accurate responses (Bowman, and Schuldt, 2014).

Part one required respondents to self-report their perceived competence over six skills (I am good at Problem-solving; Planning; Leadership; Team-working; I have self-confidence; I am Resilient against difficulties) on a 5-point Likert scale. Before moving to the next skill category, part two provided respondents with a range of curricular, co-curricular and extra-curricular activities to ascertain where they believed that their skills had been developed since they enrolled on their course.

To further reduce the potential for respondent fatigue and encourage valid responses (Leddy-Owen, 2016) these questions required respondents to select only three (not ranked) activities ('choose up to three activities that have helped develop your problem-solving skills since the start of your degree') where they believed they had deployed each skill since enrolling on their course of study.

Ethics approval for the research was secured through consent from the University's ethics committee and the research complies with the requirements of the British Educational Research Association (2018) *Ethical Guidelines for Educational Research*. The data were stored and analysed using the Qualtrics platform, which was log-in and password protected and only accessible by the project team.

All students in years 3-5 (*N= 239)* of our two degree programmes were invited to participate through receiving an email (10th March 2020) message describing the purpose of the research and information regarding confidentiality and anonymity. Two reminders were sent out (16th and 20th March) with notification of a deadline (22nd March), albeit we sought to avoid placing 'undue influence or coercion' (Norton 2009, p.181) on the students. It is noteworthy that this period coincided with the start of the Covid 19 pandemic and the University moving to a fully online learning platform. This may have impacted on the response rate.

A total of 66 students participated in the survey. From these, we discounted eight entries where the respondents had completed less that 75% of the survey. As such, a total of 58 responses (consisting of Year 3 (*N=23*), Year 4 (*N=21*) and Year 5 (*N=14*) students, *respectively)* represent the dataset. This equates to 29 % (year 3); 26 % (year 4); 20% (year 5) of the cohorts for the 2019-20 academic session. Our analysis of the quantitative data does not follow a traditional positivist approach and we do not undertake an analysis across year groups or infer statistical and generalizable propositions. The students' participation in co-curricular and extra-curricular activities are voluntary and thus the data would not be comparable; moreover, it is not possible to be precise as each student could report up to three choices of where they utilised their skills. The percentages presented in the plots of Figure 1 refer to the following n numbers:

Year 3: n = 23, except for the Resilience where n = 22

Year 4: n = 21, except for the Leadership, Planning and Self-confidence where n = 20

Year 5: n = 14, except for the Leadership, Self-confidence and Resilience where n = 13 and Planning where n = 12

5. Survey Results and Discussion

5.1. Perceived competence to the six professional skills

The majority of responses to the questions related to the perceived competence at each of the six skills included in this study fall within the agree-strongly agree categories suggesting the respondents have confidence in their abilities to deploy the six skills (Table 1). Different responses to agree-strongly agree provide a potentially easier space for tentative interpretations to be made. Nine students disagree and a further three students strongly-disagree that they have self-confidence.

In regards to leadership this skill attracted the highest number of students who 'did not know' (five) and additionally another five students who disagreed and one student who strongly disagreed that they had proficiency in this skill. This suggests that whilst some students have had insufficient opportunities to deploy and evaluate this skill, others would appear to have 'had a go' and decided they lack what they perceived to be the correct traits or skills for deployment. These findings prompted the lead author to establish a new voluntary initiative for students starting in the 2021-22 academic session. Students will be able to reflect and record their co-curricular and extra-curricular activities, and skills developed, as linked to professional civil engineering attributes (ICE, 2021). This acknowledges a recommendation (Dalrymple et al, 2021, p.78) to support students 'in evidencing and articulating [their] employability gains achieved through work-integrated learning experiences'. These author recommend the use of 'synchronous and retrospective self-reflective accounts focused on professional development'. As our programmes do not have a formal Personal Development Plan (PDP) system for students, providing an opportunity to document their Initial Professional Development (IPD) during their university studies will act as a PDP surrogate through using a student version of the attribute form supplied by the ICE. As Houghton and Maddocks (2005, p.3) note, for engineering students, PDP is the start of a life-long learning pipeline:

> For engineers, PDP can be seen as rather like IPD and CPD (Continuing Professional Development) started while at university.

INSERT Table 1: Likert Scale Questionnaire Responses (*n=58*)

INSERT Figure 1: Perceived Contribution of curricular, co-curricular and extra-curricular activities to the development of the six professional skills

5.2 .Perceived Contribution of curricular, co-curricular and extra-curricular activities to the development of the six professional skills

5.2.1. Curricular Activities

Individual activities could be considered to be student 'thinking time' that characterise their expectations of studying at university. Attending lectures, undertaking coursework and revising for exams require students to manage their own time and responsibilities, and to take responsibility for their own learning (Moran, 2000). Allocating time for private study can be challenging for all students but more so for students with competing demands on their time (e.g. part-time work, caring, mental health issues or commuting). Our data are not stratified in this manner but is evident that all three years groups considered planning to be important (Figure 1). This is a positive response given the widely held anecdotal view that students with heightened time management skills are more likely to persist, achieve higher grades and become independent learners. For some lecturers, students 'who think and plan for the future [are considered to be] the most likely of candidates to embody attributes of an ideal university student' (Wong & Chiu, 2020, p. 62).

Universities typically provide study skills advisory services to help students improve their organisation and self-management and study guides, e.g. *The Macmillan Student Planner 2020-21* (Cottrell, 2020) is a popular purchase in university bookshops. Nonetheless, despite the recognition that planning skills have been enhanced, all academics are aware of the problems with student procrastination and coursework submission behaviour (Stewart, Stott, & Nuttall, 2016).

The third- and fourth-year students were in agreement that in descending order, the next most important skills were problem solving, resilience, and self-confidence. It is pertinent to mention that, in retrospect, we could have considered asking students to rate their beliefs regarding self-efficacy. However, we considered self-confidence to provide a surrogate measure for both social and career self-efficacy (Cheng et al, 2015) rather than an academic construct. However, it is evident that the ratings for self-confidence for individual university activities are low for the fifth-year respondents and comparatively low for the third- and fourth-year respondents. This would merit further investigation given the relationship between self-efficacy and academic success.

Whilst it is recognised that being curious and 'problem finding' (Lucas, Hanson & Claxton,2014) are equally important dispositions for engineering students, it is perhaps to be expected, given its link to assessment, that students consider 'academic' problem solving to be important. Assessment is known to frame learning and influence how students allocate their time (Gibbs, 2006) so it could be argued that our students consider problem solving to be the *de facto* cognitive activity linked to assessment. However, Knight and Yorke (2003, p.70) raise an important question: 'how is it that a good problem-solver in an engineering class can fail to demonstrate problem-solving in the workplace?' The fifth-year response may suggest that they know the answer in that they rate group working more highly for problem-solving than for individual activities. This could suggest that the senior students are developing mature beliefs (albeit as novice problem solvers) about engineering problem-solving due to heightened opportunities for industry exposure. Indeed, Neves (2019b, p.15) found that 'there are in fact stark differences in students' recognition of skills development as they progress though their undergraduate studies. The fifth-year students could have transitioned from conceptualising problem solving as a 'systematic and dispassionate process of applying impartial scientific principles [towards that of considering] the human dimension in engineering problem solving' (McNeill et al, 2016, p578). In this learning space, problem finding becomes an important skill. To a certain extent this is reliant on the accumulation of tacit knowledge derived from exposure to real engineering practice. Where workplace problems typically have 'conflicting goals, multiple solution methods, non-engineering success standards, non-engineering constraints, unanticipated problems' (Jonassen, Strobel & Lee, 2006, p.148).

Undertaking engineering problem solving requires students to engage with a number of disciplinary threshold concepts (Baillie, Goodhew, & Skryabina, 2006; Male & Bennett, 2015) and some will find this new knowledge troublesome, requiring them to navigate a liminal space. It is plausible that this is partially the reason that the students rate resilience as a key skill. Indeed, in a preface to their book *Threshold Concepts in Practice,* Land, Meyer & Flanagan (2016, p. xi) talk of negotiating threshold concepts as being transformational, and, whilst this is likely 'to prove unsettling and uncomfortable' it can also be 'exhilarating, and liberating'.

Group work Activities are seen across the board to offer the best opportunity for deploying the panoply of six skills, with fourth-year students rating these highest in all but one skill (problem-solving). Whilst the interpersonal nature of group design projects, laboratories, field exercises (e.g. surveying field project) and other coursework are intended to simulate collaborative and cooperative professional behaviours, there is no shortage of evidence (Cheryl et al. 2007; Shen et al. 2007) documenting dysfunctional student group working. To mitigate such problems Greetham and Ippolito (2018) employed team-based learning interventions with civil engineering students to maximise the learning gain from subsequent project-based group work. Menekse, Purzer & Heo, (2019 p.1) 'recommend that educators should monitor team interactions and promote verbal exchanges that promote student learning and positive team outcomes'.

Based on the student responses shown in Figure 1 it is clear that curricular group work activities offer fertile ground for developing, assessing and evaluating professional skills. This concurs with Kornelakis and Petrakaki (2020, p.290) who argue 'that traditional small-group teaching activities can go a long way towards bridging the gap between graduates' skills and labour market needs'. Nonetheless, for civil and environmental engineering educators, there is also a need to introduce opportunities for students to be part of interdisciplinary and multicultural groups:

> Team working is the norm for civil engineers, and these teams increasingly include people from many different backgrounds and disciplines, and may work together for longer. It is increasingly important for civil engineers to develop team-working skills, and to acquire a broad understanding of the disciplines of others on their teams in order to work with them productively (Institution of Civil Engineers, 2018, p.32).

Across all activities in the three curricular categories, group working is considered to offer the highest potential for students to engage in leadership behaviours. This is positive given that engineering employers are known to look for leadership skills among graduate recruits (Institution of Civil Engineers, 2018). As leadership is considered to be 'both a learned and applied skill' (McCuen, Ezzell, & Wong, 2011, p.129) gaining leadership experience through group working activities provides an ideal opportunity for students to hone a range of professional skills. Knight and Novoselich (2017) have examined leadership opportunities for undergraduate engineers and concluded that whilst participation in co-curricular activities can contribute to leadership skill development, the focus should be on curricular activities as these offer wider potential to optimise leadership opportunities for all students. This concurs with Daley and Baruah (2020). Nonetheless, Montacute, Holt-White and Gent, (2021) found that less than a quarter of students in their survey considered that their university course had helped them developed leadership skills.

Leading ‘and following’ in student groups that are part of the curriculum are inextricably linked to individuals perceptions of, and contribution to, assessment, and their expected grades. Thus, self-nominated leaders, with their follower’s agreement, may satisfice through seeking to optimise grades. The introduction of self and peer review, and a subsequent requirement for the submission of a reflective report would no doubt help to refocus attention on the learning process skills, rather than solely on the output of the group working:

> For example, in group work, student reflection (self-awareness) plays a key role in helping students understand how teamwork prepares them to coordinate with others. Ideally, the group assignment itself would be transparent, reflection would feature prominently, and the ability to form a good team—not just the quality of the project—would be assessed. (Taylor & Haras, 2020 p.11)

It could be argued that both leadership and team working effectiveness increase with salience (e.g. a third-year module linked to a UK Engineers without Borders (2021) design challenge). Nonetheless, seeking to build and maintain a climate of trust and respect, and forge a collegiate interpersonal chemistry is challenging for undergraduate students. They will need to draw on their intrapersonal and interpersonal skills. Suffice to say, that this subject has received considerable attention from within the engineering discipline (e.g. Kendall, et al, 2018; Beigpourian, et al, 2019).

The Outward Bound course was introduced in the Year 2 curriculum to help students develop all aforementioned skills. As it is part of the curriculum, it is free for all students and credit bearing, i.e. all students are expected to attend. It is a bespoke course designed by the Outward Bound Trust in collaboration with the department. The Outward Bound process is designed to promote the:

> Instillation of new behaviours and skills that transfer to the participant’s home, school [in our case, university] and work environments and that improve performance (Outward Bound International, 2020).

The Outward Bound course is designed in consultation with the Year 2 Adviser of Studies, it might be that Year 2 students in one year are lacking team-working skills, while in the next year’s entry, the skill that needs to be further developed most might be their planning and time-management. The course is then adapted every year to suit the specific needs of that year and also following feedback from the students who attended in the previous years.

The feedback from Year 2 students on the course has been extremely positive consistently since 2016 when the Outward Bound trip was introduced to the curriculum. More than 98% of the Year 2 students (unpublished data) agree, or strongly agree that the course has helped them develop skills such as team-working, leadership, planning and resilience. The results of the present survey have been somewhat surprising given this previous finding. Figure 1 shows that a small percentage of students consciously perceive the course as a means to develop their skills and this percentage appears to become smaller as the students progress through their degree programme. This could be either because: (1) students ‘forget’ about the experience as time goes by, and (2) although the course is part of the curriculum, students perceive this as a ‘break’ from their studies because it is not associated with an assessment on the more traditional subjects (geotechnics, structures etc.) rather than an opportunity to develop their skills.

5.2.2. Co-Curricular Activities

Co-curricular activities are known to have a positive influence on students learning and employability skills (Busby, 2015; Dean, 2015) and provide opportunities for integrating systems thinking into civil and environmental engineering education (Hall et al, 2020). Furthermore, UK engineering students are known to place a premier value on internships, placements and volunteering as a means to enhance their employability (Wood, Findlay and Resalat, 2020, cited in Wood, 2020). This is consistent with findings of a study (Neves and Hewitt, 2020) revealing that students believed that securing work experience during their studies is a key requirement to ensure post-graduation success. However, there are concerns over a ’work experience gap’ in UK universities (Universities UK, 2018a, p.15). Tennant et al, (2018) found a significant undersupply of civil and environmental engineering placements in the west of Scotland. The Covid 19 pandemic has compounded this issue with engineering employers reported to have reduced the recruitment of interns and placement students by about 50% (Institute of Student Employers, 2020). Looking forward, the Construction Leadership Council (2021) has called for an improved availability of effective work placements, aided by a sectorial portal to improve the industry-academic interface. That said, students themselves have voiced concerns about how Covid has impacted on their access to placements and field trips. Neves and Hewitt (2021, p.62) concluded that ‘the lack of access to these have limited their perceptions of the value gained from their higher education experience’.

The students who had secured a self-placement reported that they had opportunities to engage in problem solving and team working, albeit for all students there is a perception that these skills, particularly team working, are more prevalent within university group activities. This could indicate that the temporary nature of placements presents some barriers to the affiliation of students into departmental work streams. Students making comparisons with working with friends in groups at university. The values are typically higher for the fourth- and fifth-year year students given they have had more opportunities to secure a placement than the third-year students. It is of significance, albeit not surprising, that the students consider placements to offer significantly less opportunities to deploy leadership skills compared to group activities at university. If we consider student placements through a lens of ‘communities of practice’ (Wenger, 1998) and the student role as novice engineer engaging in ‘legitimate peripheral participation’ (Lave and Wenger, 1991) then it is understandable that there would be fewer opportunities for student agency with regards to leadership, a summer employment relationship akin to an apprenticeship. Nonetheless the students report increases in self-confidence and building resilience. These skills align with the concepts of identify transformation and ‘becoming’ a professional that feature in Lave and Wengers (1991) work.

The students’ perception on the contribution of Constructionarium to the development of their skills was unexpected, especially taking into consideration that the host construction company pay considerable attention to communicating to students the need for planning and teamwork skills. Surprisingly, these skills did not feature particularly prominently in the students’ responses. The fifth-year students have an overall higher appreciation of the opportunities to deploy these skills. Constructionarium offers students an authentic industrial experience, second only to a disciplinary placement, so this may be a sign of disciplinary maturity and a firmer understanding of what activities and skills have relevance to their impending career.

All three year groups consider the problem-based workshops to provide opportunities for problem-solving and team-working, which is to be expected. Given that the workshops are not credit bearing, Murray, Hendry & McQuade, (2020) concluded that the informal climate prevalent during workshops had helped to de-risk some of the traditional problems that are known to result in student engineering team projects becoming dysfunctional (Cheryl et al. 2007; Shen et al. 2007). It is encouraging to see that all three groups considered the problem-based workshops to offer opportunities to engage in leadership.

The responses to the contribution of attending ICE and similar events suggest that such activities provide only a little value to enhancing students' professional skills, albeit this does mask the technical knowledge that would typically be gained through attendance. It could have been expected that more students would have considered attendance at professional institution events to have bolstered their self-confidence, albeit this could be dependent on their motivation to floor technical questions and to mingle purposefully with more senior engineers before and after the events.

5.2.3. Extra-Curricular Activities

Our results show that respondents considered that working for a non-engineering employer primarily enhanced their leadership, self-confidence and resilience skills. This confirms Trevelyan (2014) who argued that you do not have to be working in an engineering job to develop leadership and team working abilities. Murray et al, (2019) found similar views of civil engineering students employed in non-engineering summer jobs, with self-reported improvements in their communication and team-working skills. Of note, Evans & Yusof (2020) have argued for students' who secure part time work to consider how this can help demonstrate the skills required in their future professional careers, and, for employers of students to consider how they can assist them in skills development rather than only monetary benefits.

Students who participate in group activities (e.g. Scout and Guide movement, sports clubs and musical groups) thought that these activities enhance all of the six skills and primarily their team-working, leadership and self-confidence skills. In regards to carer responsibilities, fourth- and fifth-year students suggesting that this helped build resilience, whereas third-year students suggested there had been leadership and problem solving legacy gains. These findings concur with research (Sempik and Becker, 2014; Neves, 2019b) demonstrating that students can make good use of the transferable skills gained within their caring role. However, student carers can be at risk of not achieving their full potential (Scottish Funding Council, 2020) and can find it difficult to balance their university studies with their other commitments (NUS, 2013).

Extra-curricular activities undertaken by students during term-time and over the summer vacation are 'off-piste' and are not usually communicated to academics. This could be contributory to students underestimating how significant these activities are in developing employability skills (Swingler et al, 2019), particularly where the activities do not align directly to the students' future career path (Dickinson, Griffiths & Bredice, 2020). However, there is contradictory evidence in a UK student survey undertaken by Neves (2019b): 'there is positive evidence that students still recognise the importance of a range of extracurricular activities [and the report] provides a range of evidence as to why these activities should be supported' (Neves, 2019b, p.4). As an aid to supporting students Perkins (2017, p.18) recommended that HEIs should 'establish a longitudinal summer activities survey to help inform the strategic employability direction of universities'. The JBM (2021) appear to concur with this view. They make an explicit reference to 'extra mural activities' for HEI's offering civil and environmental engineering programmes:

> It should also be remembered that many qualities upon which employers place considerable importance are developed by involvement with activities external to the department, so these should be encouraged. (p.39)

5.2.4 Limitations

The self-reporting questions (Table 1) seeking to gauge the students' perceived competence over the six skills are likely to have been interpreted differently by each student. Conceptualisations of what constitutes being "good" at problem-solving; planning; leadership and team-working will be context laden for each student, their perceptions will be dependent on prior experience deploying these skills and the outcomes. Equally, the student responses that involved reflecting on, and evaluating their intrapersonal ("I have" self-confidence and "I am" resilient) skills need to be considered in light of potential optimism bias. Moreover, given the high number of responses in the "agree" and "strongly agree" categories these could be subject to acquiescence bias, which refers to the respondents' tendency to agree with statements rather than disagree (Toner, 1987, cited in Nadler, Weston & Voyles, 2015, p.72).

Furthermore, there is potential for social desirability bias and the respondents may have contrived to provide an 'overly positive self-representation on [the] self-report questionnaires' (Coulacoglou & Saklofske, 2017, p.274). Kruger and Dunning (1999, p.1132) refer to people holding 'overly optimistic and miscalibrated views about themselves'. This is particularly problematic in self-reporting surveys where respondents may be unaware of their own fallibility in 'anticipating the likely accuracy and error of one's responses and this lack of insight often extends to situations in which people attempt to estimate their performance on a particular task or test' (Ehrlinger and Dunning, 2003, p.6).

The Dunning-Kruger effect has been noted in other studies of engineering students' perception of competency in generic skills (Chan, Zhao, & Luk, 2017). These authors found 'it was unclear as to what extent this effect would be found with measures of generic skills in our study and with engineering students in particular (p.317). Nonetheless, if the Dunning-Kruger effect premise continues to hold true, then this would suggest that our poorer performing students have less metacognitive competence to evaluate their perceived competence over the six skills, and will have overestimated their competence. To address this issue, and to improve the trustworthiness of the data in future student self-reported surveys, it will be necessary to enhance our students understanding of the role of metacognition in their learning. The employment of formative 'curricular' assessments requiring self and peer review (particularly in group work) could act as a catalyst for assisting our students to develop an awareness of the Dunning-Kruger effect, and to be cognizant of its potential impact in co-curricular and extra-curricular activities where they would benefit from evaluating their own competences. This would enhance their own reflections in and on learning and ideally provide more reliable and rigorous data for future surveys investigating students' perceived competence over the six skills.

In regards to the co-curricular and extra-curricular activities, the response (%) figures should be treated with caution. As these activities are voluntary, the respondents may have engaged in none, some or many of these activities. As such, the % figure may not necessarily be representative of the sample. In addition, the response options limited the respondents to selecting only their top three activities for the deployment of each of the six skills thereby shaping the profile of the results (Bowman and Schuldt, 2014).

There is limited space in this article to discuss this more fully but there are likely to be a myriad of contextual factors that impact on student's self-confidence, and arguably, this skill is the linchpin for the deployment and optimisation of the other five skills, particularly resilience where six students (Table 1) reported concerns in this skill. We support the call for more widespread research on student resilience in HEIs (McIntosh and Shaw, 2017; Holdsworth, Turner & Scott-Young, 2018; Ryan, et al 2019). Moreover, emerging research into the impact of the Covid-19 pandemic (2020-2021) on the student experience suggests the need to keep an open mind - *Student learning during COVID-19: It was not as bad as we feared* (Lee et al, 2021).

6. Discussion

The engineering profession (Ridley, 2017; ICE, 2018) has called for universities to provide their graduates with, at least, an awareness of the soft skills they will need to deploy during their careers. Overall there have been noticeable improvements made by HEIs in incorporating soft skills within engineering education. Nonetheless, there continue to be calls (Hall et al, 2020; Valero et al, 2020; Winberg et al, 2020; Montacute, Holt-White & Gent, 2021; McVitty and Andrews, 2021) for soft skills to be embedded within the university curriculum. To aid this process, Berdanier (2022) has called for a '*A hard stop to the term "soft skills"*' and for engineering academics to 'call these professional skills what they are. They are not "extras" and not at all soft' (p.16). Our findings concur with these recommendations in that our students considered group-working activities to provide rounded opportunities for road-testing their professional skills. On the other hand, Caeiro-Rodriguez et al (2021, p.29240) submit that developing appropriate soft skills assessment instruments for engineering education is a 'complex problem, and subjective to a certain extent'. Engineering signature pedagogies and assessment regimes tend to value scientific rigour. This is pertinent to our findings given that the questionnaire did not explicitly require the students to consider the assessment of professional skills within the curriculum. As our department has no policy on the incorporation of professional skills within the curriculum, module registrars have a degree of agency to make their own interventions. Anecdotal evidence suggest that some of our colleagues have embarked on this process through the introduction of peer evaluation and, or peer assessment in group work settings. This may have had some influence in the student responses.

In regards to the Outward Bound course, as noted earlier, we were surprised by the responses given that the department has post-course feedback from students that suggests an extremely positive outcome in regards to enhancing their skills. The problem is likely to be the interplay between how students value their Outward Bound learning (surface, deep, strategic) and how the department provides opportunities for 'assessed' reflective practice, and, or incorporating reflective writing within a PDP portfolio. Nonetheless, we envisage that our students have transferred some of their skills learning from the course to university group working tasks. Particularly given the similar requirement for the deployment of their intrapersonal and interpersonal skills.

The co-curricular activities undertaken by our students provide opportunities for enhancing their professional skills. However, in regards to how they influence student learning the activities are largely indistinguishable from extra-curricular activities. Without acknowledgement by the department, co-curricular and extra-curricular activities are largely invisible to academic staff. As such, the potential for creating synergy with the curriculum is diminished. Perkins, Gibson and Hickman (2017, p.7) recommend that 'personal and professional transition skills, gained during summer activities, is worthy of further investigation, potentially by creating the framework of a credit-bearing course'. Furthermore, Evans (2021, p.10) called 'for university lecturers to embrace students' part-time work experience and use it to enhance the learning, teaching and assessment experience'. Typically, universities provide students' with opportunities for capturing the learning gain from extra-curricular activities through a PDP system, or through using the Higher Education Achievement Report (HEAR) (Burgess, 2007). Wilson (2012, p.41) urged universities who had not committed to HEAR (including the authors' university) to 'reflect upon the impact of that decision upon the skills development and subsequent employment prospects of their graduates'. Moreover, the Engineering Professors Council (2019) have argued that the use of HEAR could help alleviate some of the concerns about grade inflation in HEI's (Universities UK, 2018b):

> The engineering community would strongly support a multi-dimensional approach to assessment which would allow for recording what has been achieved by each student with greater granularity (p.2).

7. Conclusion

Whilst our findings have a number of limitations, it would be appropriate to undertake a review of our full-time programmes, to decide on our priorities for the tracking, assessment and evaluation of professional skills (McVitty and Andrews, 2021; Munir, 2021). To 'create a framework that allows the skills to be embedded into the programme and determine methods of instructing, practising and assessing those skills' (Clarke, 2005, p.84). This will require a holistic approach whereby the professional skills required by industry are clearly communicated to students (and academics) before enrolment, and assessed (Andrade, 2020; Berdanier, 2022) during university studies.

Moving forward, the task is twofold. One, there is a need to educate our students to uncover their own epistemological beliefs on learning professional skills, and to encourage them to take a positive attitude towards developing these skills (Chan, Zhao, & Luk, 2017; Cave et al, 2018; Succi & Canovi 2020; McVitty & Andrews, 2021). As noted in section 5.1, as an outcome of this research the lead author has established a new voluntary initiative for students starting in the 2021-22 academic session. This will allow students to reflect on, and document their co-curricular end extra-curricular activities as IPD, during their university studies, and to link their knowledge and skills to professional civil engineering attributes (ICE, 2021). As the Accreditation Board for Engineering and Technology. (ABET, 2021) have argued, 'the cumulative result of student learning in our curricula and co-curricular activities enables the career and professional accomplishments of our graduates'.

Secondly, academics are encouraged to use pedagogies that promote learner agency (Matheson & Sutcliffe, 2018; Kamp, 2020) and incorporate opportunities for the measurement (Cronin et al, 2019; Byrne, Weston, & Cave, 2020) and assessment of professional skills that reflect professional disciplinary practices in the curriculum (Rich, 2015; Cachia, Lynam & Stock, 2018; Swingler et al 2019; Dicker et al, 2019; Kamp, 2020; QAA Scotland, 2020; McVitty and Andrews, 2021). To that end, Caeiro-Rodriguez et al (2021, p.29240) have set a challenge for HEIs: 'it would be desirable to have available assessment instruments that were easily implementable and reproducible, that can provide precise evaluations about the level of soft skill mastering of a person'. These requirements are likely to require 'staff development and support', 'particularly…when introducing or integrating professional skills into existing programmes' (Winberg et al 2020, p173). Indeed, Picard et al (2021) have called for more research with teaching staff to understand how they support students to develop professional skills. To that end, Beagon (2021) found that engineering academics in Ireland had different conceptions of the professional skills required by their students. She recommended that any curricular reform involving professional skills should acknowledge the 'multifaceted way of understanding to encourage all academics to engage in the process' (p.182).

Given the ongoing disruption in HEI's due to the Covid pandemic, and a need for civil engineering programmes to address the climate emergency, (JBM, 2021) whilst equipping our students with 4th industrial revolution skills (Mtshail & Ramaligela, 2021) Rahm Emanuel's maxim of 'you never want a serious crisis to go to waste' (Maley, 2020) could be the call to arms. Indeed, there is evidence that the Covid pandemic has led to innovative practice and a re-visioning of employability practice (Norton and Dalrymple, 2021) and soft skills pedagogy (Rovida & Zafferri, 2022) in engineering education.

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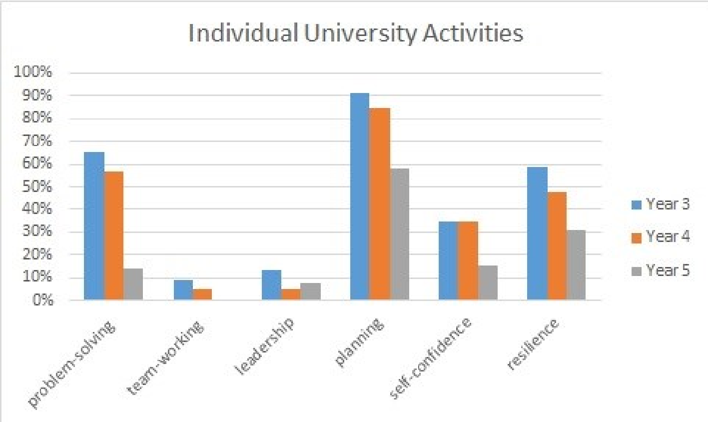
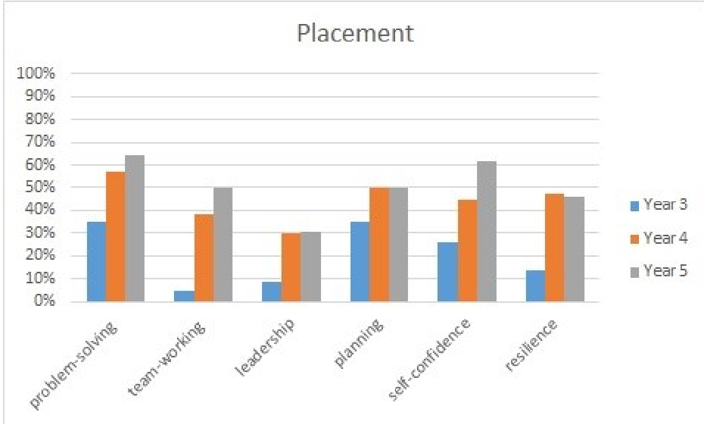
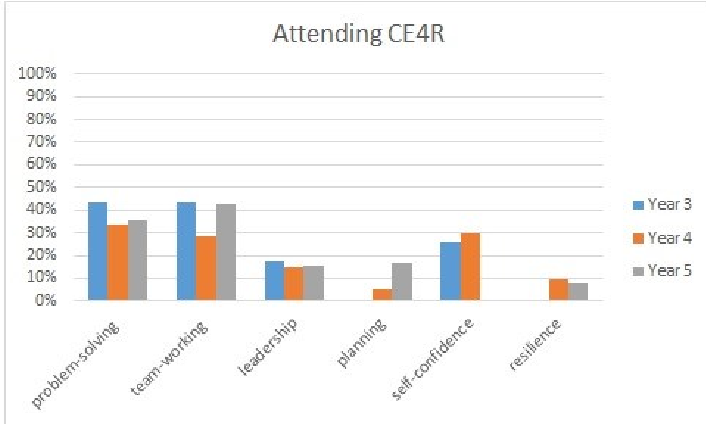
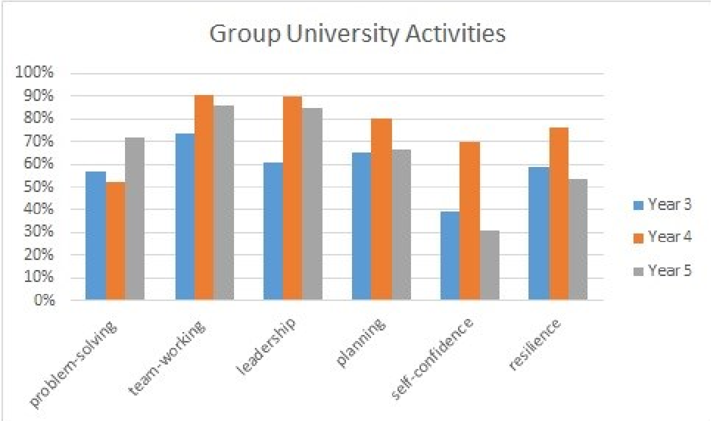
Table 1. Likert Scale Questionnaire Responses (*n=58*)

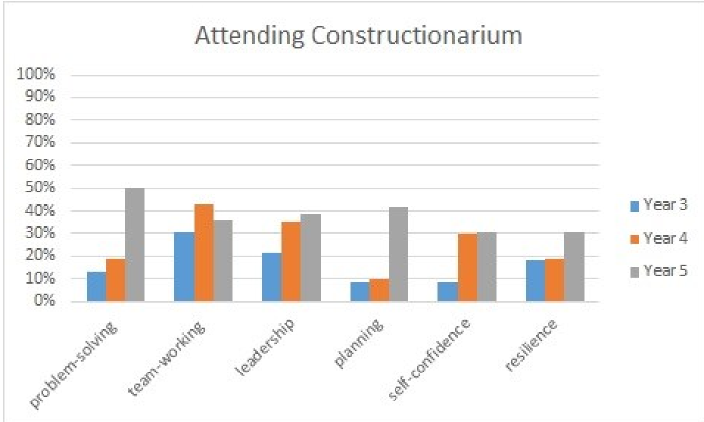
	Year	Strongly Disagree	Disagree	Agree	Strongly Agree	I Don't Know	Total
I am good at problem-solving	3	0	1	17	5	0	23
	4	0	0	12	9	0	21
	5	0	0	8	6	0	14
	Overall	**0**	**1**	**37**	**20**	**0**	**58**
I am good at team-working	3	1	0	18	4	0	23
	4	0	1	7	13	0	21
	5	0	0	3	10	1	14
	Overall	**1**	**1**	**28**	**27**	**1**	**58**
I am good at leadership	3	1	2	15	4	1	23
	4	0	2	11	7	1	21
	5	0	1	5	5	3	14
	Overall	**1**	**5**	**31**	**16**	**5**	**58**
I am good at planning	3	2	0	16	5	0	23
	4	0	4	11	6	0	21
	5	1	1	7	4	1	14
	Overall	**3**	**5**	**34**	**15**	**1**	**58**
I have self-confidence	3	1	5	12	5	0	23
	4	1	2	13	5	0	21
	5	1	2	6	4	1	14
	Overall	**3**	**9**	**31**	**14**	**1**	**58**
I am resilient against difficulties	3	0	2	19	2	0	23
	4	0	4	10	5	2	21
	5	0	0	10	3	1	14
	Overall	**0**	**6**	**39**	**10**	**3**	**58**

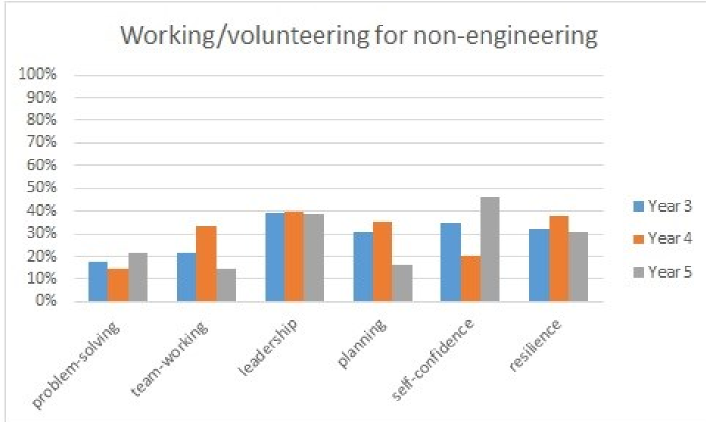

Individual University Activities
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5

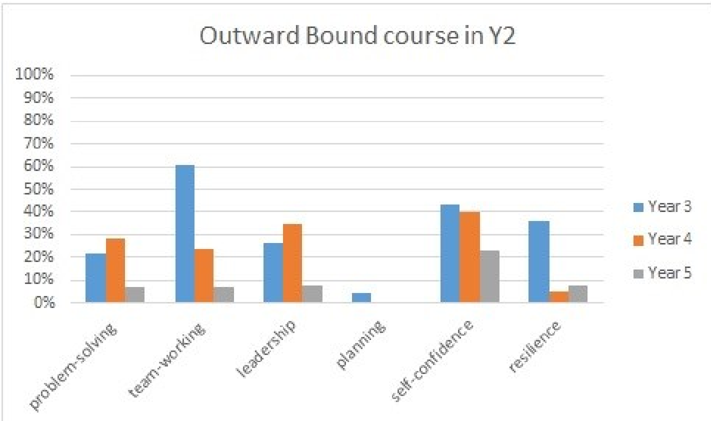

Placement
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5

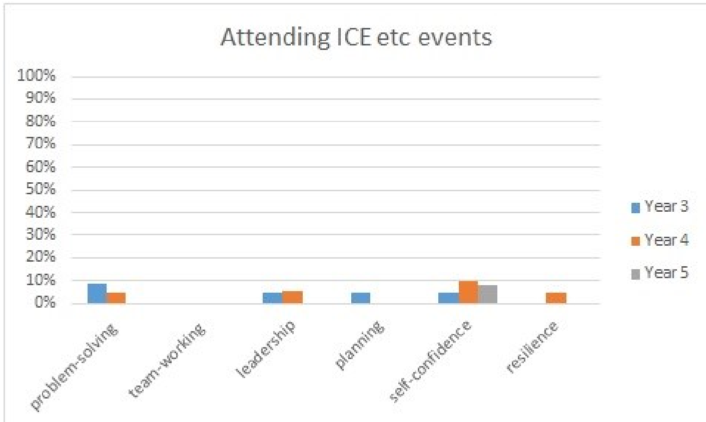

Attending CE4R
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5


Group University Activities
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5


Attending Constructionarium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5


Working/volunteering for non-engineering
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5


Outward Bound course in Y2
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5


Attending ICE etc events
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5

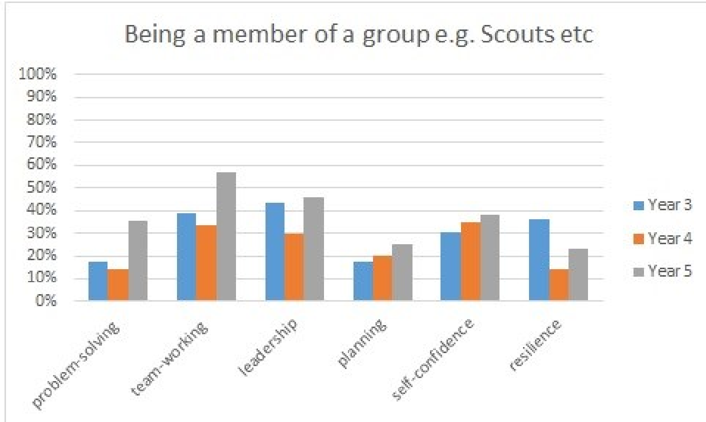

Being a member of a group e.g. Scouts etc
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
problem-solving
team-working
leadership
planning
self-confidence
resilience
Year 3
Year 4
Year 5

Figure 1: Perceived Contribution of curricular, co-curricular and extra-curricular activities to the development of the six professional skills