Exploring Graduate Perspectives on Curricula Design in Engineering Education

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ABSTRACT

When designing a curriculum, engineering academics have a number of influencers shaping the process including student expectations, accrediting body requirements and the needs of employers in filling often very diverse graduate roles. They also consider modes of teaching which often balance best practice and resource constraints. Feedback from accreditation visits, module questionnaires and industrial advisory boards help iterate and revise the curriculum, etc. and while these are useful, they may often be indirect or inappropriate measures of the effectiveness of our programmes in the workplace.

An area the sector in general has less hard information on are reflections of graduates on specific elements of their undergraduate learning experience once in industry. The survey presented here is part of a wider mixed methods approach which will also involve initial destination data and interviews with graduates.

The work presented here is based on a survey of selected graduates from a particular degree family over the past decade. The curriculum has been broken down into five areas typical of many degrees; traditional engineering science, applied engineering skills (eg. CAD, Quality), internship, group design build and test projects and their individual thesis project with graduates asked to reflect on the impact and value of each of these on their subsequent working life as a graduate engineer.

1 INTRODUCTION

The development of curricula in engineering education is influenced or defined by a number of factors. These may include the need for professional body accreditation such as ABET [1] in North America or the Engineering Council [2] in the UK which typically define core academic competencies of professional engineers. Local and national employers will also influence academic teams in their construction of curriculum via the use of industrial advisory boards and graduate recruitment patterns [3,4]. In addition ‘employability’ – an umbrella term to help cover both the technical and personal qualities required of graduates into industry, together with sustainability has become of increasing importance to curriculum developers in recent years [5]. The students themselves are also naturally key influencers in ensuring that the programmes offered are competitive and attractive in the face of numerous alternative offerings [6,7]. These influencers together with the likes of external examiners will also act to scrutinise the suitability and operation of the programmes.

If however the aim of a degree is to equip graduates with the skills needed to transition into and develop once in their professional careers it could be argued that many of the commonly used measures to draw up and review degrees are indirect and do not close the loop on the effectiveness of programmes. Learning outcomes defined by accreditation, for example, may be quite generic and give a syllabus template which **should** deliver the competences the graduates are thought to need. Student surveys while offering a timely measure of contentment with teaching style and organisation are poorly placed to act as measure of the relevance of content.

An area which is not routinely used to develop and adjust programmes is the reflective experience of graduates of the programmes and how the degree they did supported their careers [8,9]. Arguably this is a key measure which truly closes the loop on the effectiveness of programmes.

The aim of the work presented here was to explore and compare how on reflection different elements of a degree are valued by graduates once in the workplace.

2 METHOD

2.1 Methodology

It was decided that an anonymous online survey of engineering graduates from a set of programmes at Aston University, UK would be carried out. This will form part of a wider study with the intention to follow the survey up with a series of interviews to consolidate and explore key points of the survey data. This further activity is beyond the scope of this current paper.

The online survey was chosen as a practical approach to ensure both the anonymity of the respondents and the efficient and consistent gathering of data for a geographically disparate group of individuals.

Approval for the survey and associated methodology were sought and granted by the Aston University Engineering and Applied Science ethics committee.

2.2 The Survey

While focussed on the experiences of a particular degree family at a specific UK University the survey was structured to draw on key components of many degree programmes to help offer the opportunity for lessons learned by this work to be more transferable.

The main content of the survey therefore looked at 5 elements which feature in many engineering degrees :

- Conventionally taught core engineering science and mathematics
- Applied engineering science *(CAD / Manufacturing / Quality / Society etc.)*
- Project based learning (PBL) *(Whole class projects with students working in groups)*

- Major final year project / dissertation (FYP)
- Industrial internship / placement *(Year long paid placement in industry)*

The survey had three sections.

- Demographics : This featured broad categorised basic information on when the individual graduated, industry sector and current role.
- Main content : for each of the 5 programme elements students were asked if they used the content taught directly, if it underpinned what they did even if not used directly and if the element developed transferable skills used in their current role. This was done via a 5 point Likert scale in each case and participants could add further comments if desired.
- Further comments : Participants were offered on opportunity to offer areas of curriculum they would have liked to have added, to have dropped or make any other comments.

2.3 Participants

The graduates recruited for this study were those sourced via the author, a former programme director's "Linkedin" network and were individuals who had graduated from the Mechanical Engineering family of undergraduate programmes at the parent University over the previous decade.

For the programmes involved, participants who graduated 6 or more years ago followed a relatively traditional curriculum, while a more project based learning (PBL) focus following CDIO principles was introduced for the more recent graduates. CDIO is an educational framework stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating (CDIO) real-world systems and products. In addition to the projects embedded in the taught degree, the University also encourages students to undertake a year long industrial placement however this is not compulsory.

Around 80 former students were approached with 32 completing the study. 20 of the students graduated over the last 5 years and followed a programme with significant PBL content with 12 graduating 6 years or more ago and following a more traditional curriculum. 16 of the 32 total took a year long industrial placement.

Mechanical engineering graduates have a diverse range of careers, in highly varied industry sectors and this was reflected in the roles of those surveyed. A breakdown of the industry sectors in which the graduates operate can be seen in *figure 1.*

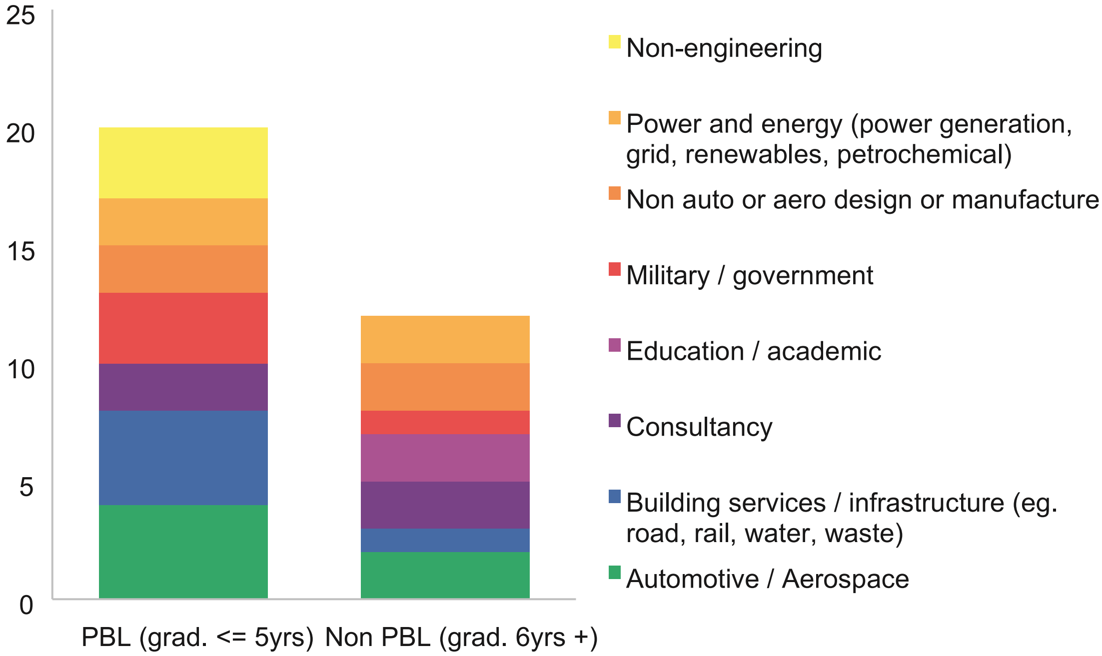


Fig. 1. Industrial Sectors of Graduates Participating in Survey

3 RESULTS

Figures *2* to *4* show the aggregated results from the survey where in each case the graduates were asked, for each of the five programme elements, whether in their daily work they used these directly, whether they underpinned what they did and whether the modules helped them develop the transferrable personal and professional skills needed in their role.

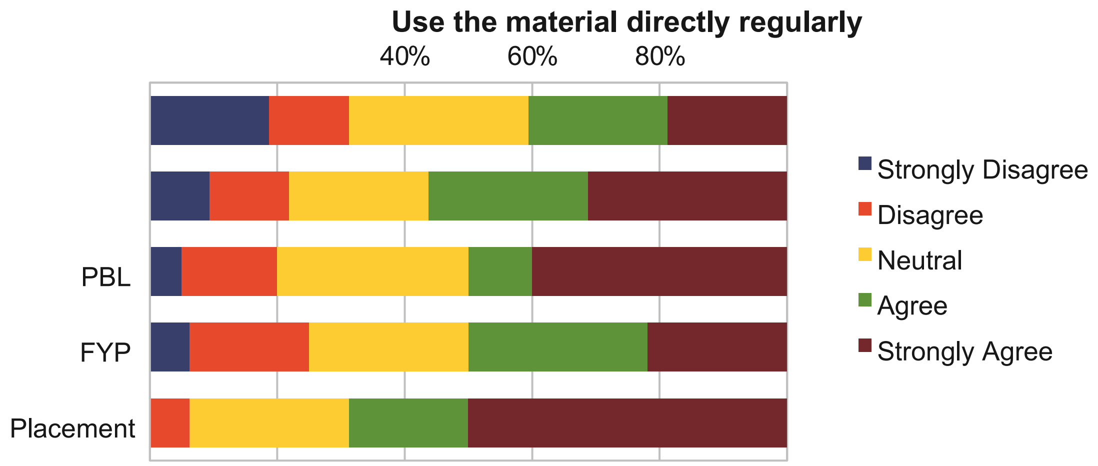


Fig. 2 : "I use some of the formally taught knowledge and skills gained in *(programme element)* directly on a regular basis"

Figure 2 shows the extent to which graduates directly used the material taught to them in each of the programme elements. Most notable is that for the classic engineering science modules which form a significant part of most degrees, relatively few students call on this first principles knowledge directly on a day to day basis. This element is not on its own however with the final year project, PBL and applied engineering sections showing hovering around 50% of responses clearly positive. This might not be unexpected given the range of diverse and specialist roles graduates find themselves in where the regular application of the basic broad fundamentals are more likely to be surpassed by industry specific tools and techniques. For some however, particularly those working in perhaps research areas, core skills will still be key as indicated by a comment from a graduate working in research and development in the power generation sector :

"I use the skills learned in Solid Mechanics, Thermofluids, Heat Transfer, Engineering mathematics, Turbomachinery on a daily basis."

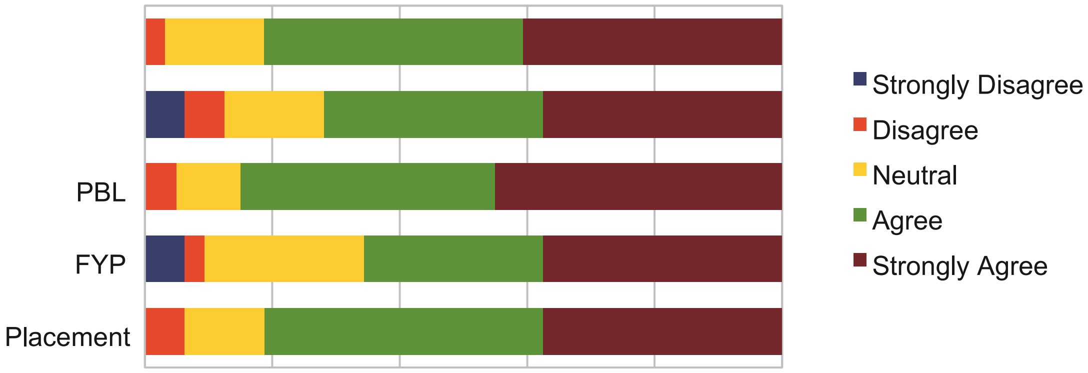


Fig. 3 : "Whether or not I use the knowledge formally gained in *(programme element)* directly, I feel it underpins much of my daily work"

Figure 3 shows that the graduates appreciated that even if they may not use the formal learning in a direct sense on a day to day basis they appreciated that derivatives from this work informed their role and adds to the depth of understanding of their current processes.

From a graduate working in the military / government sector :

"While I do not use all of the skills directly they have enabled me to become a CEng and allow me to retain a level of credibility when discussing technical subjects."

From another along the same vein

"The tacit knowledge, vocabulary and understanding is invaluable as an aid for working alongside engineers with a deep technical specialism and translating / facilitating their conversations with the business functions."

Figure 4 shows the impact of those transferrable skills elements embedded in degree programmes which help to develop the wider personal and interpersonal qualities of the individual. It was clear that graduates felt this was important and had been a positive support to their career. In particular the project based learning element and the placement appeared extremely strong in this area with in both cases around three quarters of graduates strongly agreeing that it had helped them feel comfortable with more general problem solving, organisational, investigation or personal and interpersonal skills in their daily work.

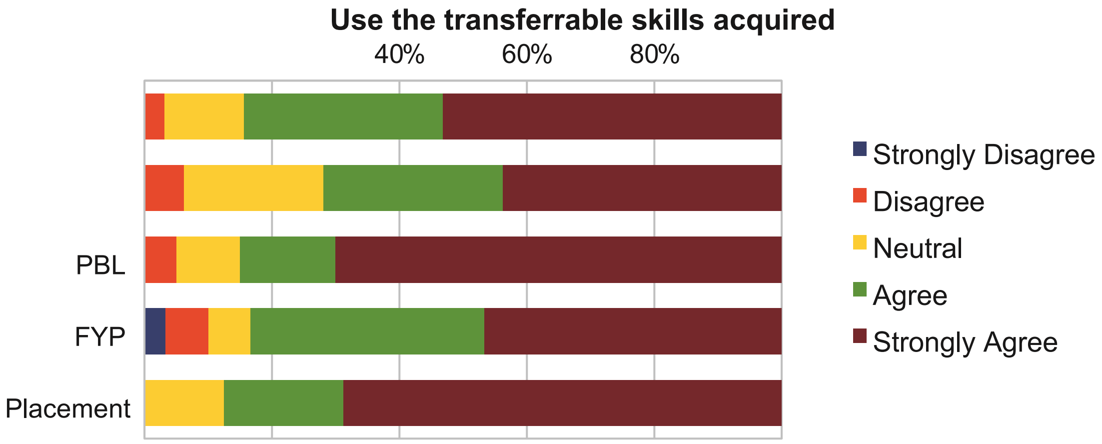
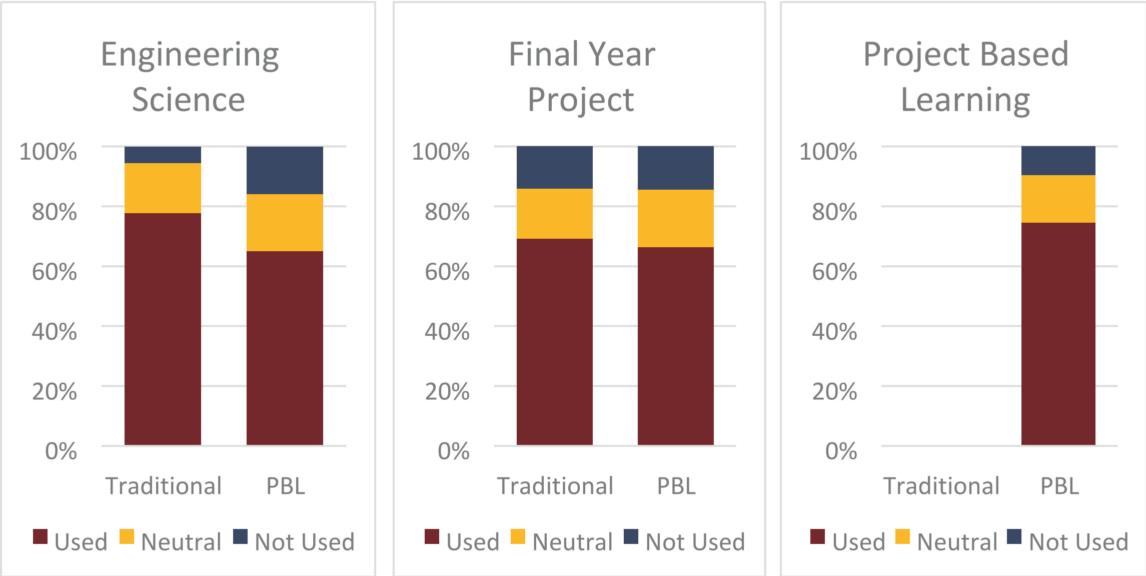


Fig. 4 : "The *(programme element)* helped me feel comfortable with more general problem solving, organisational, investigation or personal and interpersonal skills in my daily work"

In regard to the PBL elements some comments from surveyed graduates included :

"….provide a link into reality of engineering problem solving and team work. This section of the degree provided good foundation for project / schedule management skills, working within teams and general applied engineering" and "*The skills garnered in PBL have been a constant part of my tool set as I have progressed through my career."*

The students involved in this study graduated over the course of a decade. While the programme structure and detail content varied and evolved over this time, the core elements of engineering science, applied engineering topics, final year project together with the option of an industrial placement were constant. Midway through the decade a major change however was the introduction of project based learning elements designed to make the learning more effective and industry focussed. As part of this work we wanted to see if this element was valued ?



Engineering Science *(a)* | *Final Year Project* *(b)* | *Problem Based Learning* *(c)*

Fig. 5 : Aggregate comparison of reflections of three programme elements as featured in the traditional and PBL focussed degrees.

Figure 5 shows aggregated results for students on the older, traditional programme versus those on the PBL aided model. For each programme element a comparison has been drawn by aggregating all the Likert responses which indicated use / neutral / limited or no use for direct / underpinning or transferrable skills in the graduates current working role.

For the engineering science element *(Fig 5(a))* there does appear to be some slight dropping away of the use to which the more recent graduates place on this. A similar pattern was also observed in the applied engineering section. The follow up interviews will explore this issue to investigate whether this is a genuine trend, a statistical blip given the relatively small numbers surveyed or is related to the increased emphasis on PBL in the newer degree. This element has been well received and its relevance to graduates as can be seen in *Fig. 5(c)*. By contrast *Fig 5(b)* shows a very consistent appraisal of the relevance of the final year project.

4 DISCUSSION AND SUMMARY

Graduates are the key product of engineering programmes. Academic teaching teams work hard to try to deliver effective programmes, balancing constraints of resource with the demands of a range of influencers whether these be their own institutions policies, accrediting bodies, current and future students, external examiners and industrial boards. Graduates themselves the consumers of the programmes and those who have direct experience of taking the learning into industry are often not part of many formal review processes.

This work has taken some steps in this direction. It shows that, for the graduates participating in the survey, taking a degree has been important in preparing them for and supporting them in their work life. All components of a degree programme whether the conventional engineering science, placement or final year project deliver direct, underpinning or transferrable skills giving positive benefits to graduates in the workplace.

It does however also pose some questions.

While the results were generally highly positive there were some students who reported less than optimum and negative responses for some aspects of some elements. It may be that this may be inevitable given the broad range of sectors and roles to which graduate mechanical engineers may go to – a perfect course for a graduate engineer in the rail sector is unlikely to similarly suit an individual working in manufacturing or biomedical engineer sector.

For analysis and transferability, the programme used in the study was broken down into five programme elements common to many degrees. While this was an efficient way to segment the degree it also needs to be recognised that in doing so each element was characterised by a blend of both different content types and different learning modes. Isolating the effectiveness and relative importance of these two aspects of each element will be explored in future interviews.

It is intended that this work will be expanded. Potentially some further students are to be surveyed while semi-structured interviews will be carried out to explore and deepen the understanding of some of the issues raised. This will also look at longitudinal issues to reflect that over a decade, regardless of internal issues of content and format within a programme, the students embarking on their studies together with market and societal issues will also change and these could also be reflected in graduate views on the merits and suitability of their degree.

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