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Where are we at with combined engineering degrees?

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ABSTRACT

CONTEXT

Combined degrees (also referred to as double or dual degrees) allow students to complete two degrees concurrently, widening their learning experiences and broadening their skills, which leads to engineering graduates with greater diversity in skills, who are often well regarded by industry (Shallcross & Wood, 2002; Fleming et al., 2010). With an increasing need for breadth of knowledge and skills in graduate engineers, the ACED Engineering Futures 2035 Scoping Study (Crosthwaite, 2019) suggests some models (including combined degrees) that could contribute to a greater shift away from the current range of program structures that focus solely on engineering. There are nevertheless some concerns around the combined degrees, particularly around the merits of technical depth vs breadth of knowledge and experience, as well as the subsequent industry-readiness of graduates. Furthermore, there have been many calls for integration across the two degrees of combined degree offerings (Russell et al., 2008; Moulton, 2011); however, little has changed.

PURPOSE OR GOAL

The aim of this study is to explore and discuss the current opinions around combined engineering degrees, particularly in terms of the following themes:

- depth vs breadth in engineering degrees
- industry-readiness of combined engineering degree graduates
- integrating the components of the combined engineering degrees

APPROACH OR METHODOLOGY/METHODS

A literature review on combined engineering degrees was conducted. This was expanded with data from University of Sydney participants in the form of semi-structured interviews with academics (n=5), as well as an online survey of current and graduate combined degree students (n=14). Although a small sample from a single institution, our data nevertheless highlights a range of current opinions on combined degrees.

OUTCOMES & CONCLUSIONS

Both the existing literature and our data suggest that, although the combined degrees are regularly suggested as a means to develop well-rounded engineering graduates of the future, there continue to be concerns around the utility of the degrees in developing technically-competent engineers and there is little impetus for significant structural change to the degrees. More can be done to explore opinions from other institutions and identify in what ways the responses in this study are influenced by institutional structures; however, this paper highlights that there are nevertheless a number of concerns with the combined degrees that need to be addressed by the engineering education community.

KEYWORDS

Combined degrees, industry-readiness, depth vs breadth

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Introduction

Prior to the 1980s, Australian engineering students who wished to complete a second undergraduate degree needed to undertake both degrees separately, usually taking 7 to 8 years; however, since then, the introduction of combined degree programs has given students the opportunity to concurrently complete two degrees within a shorter period (Shallcross & Wood, 2002). According to Engineers Australia's (2019) accreditation criteria, combined degrees take substantially less time than the two component degrees as there are content and learning experiences that may validly be counted towards both qualifications. This often falls under the approximately 10% of the engineering degree that is "*more of [engineering-specific content] or other elective studies"* (approximately 1 semester).

The range of undergraduate engineering combined degrees currently offered in Australia broadly include those with Science, Arts, Business, Law, Architecture, Project Management and Design. The full-time duration of a combined degree ranges from 5 to 5.7 years for combined degrees other than Law, and 6 to 6.7 years for combined degrees with Law. In the case of non-Law degrees, some universities' combined degrees offerings are a flat 5 years (e.g. The Australian National University, Monash University and The University of Sydney), whereas other universities' combined degree offerings vary in length depending on the non-engineering component (e.g. UNSW's engineering degrees typically combine with: Science in 5 years; Arts in 5.5 years; and Commerce in 5.7 years). Regardless of institution, Engineering/Science degrees are all 5 years in length due to the Science degree's capacity to contribute to the Engineers Australia's (2019) accreditation criteria of "*underpinning mathematics, science, engineering principles, skills and tools appropriate to the discipline of study and qualification*".

Students enrol in combined degree for a variety of reasons including enhancing career prospects, uncertainty around which career they wish to pursue, widening their breadth of learning, as well as completing an engineering degree while also pursuing other subjects of interest (Shallcross & Wood, 2002; Lever et al., 2011). Much of the university marketing around combined engineering degrees also draws on these points, e.g. UNSW indicates the combined degree will help "*develop your skills in two separate areas, achieving more in less time and opening the door to more opportunities*" (UNSW, n.d.) and The University of Queensland comments that a combined degree is an opportunity to "*[d]ouble your skills and your opportunities*" (The University of Queensland, n.d.). Furthermore, according to Lawrence (2020), high school students tend to be more aware of the non-engineering degree of a combined engineering degree as contrasting with, rather than building upon, the engineering degree.

Combined degree programs can drive increases in student enrolments in engineering. Crosthwaite (2019) has indicated that, at some institutions, the engineering graduates from combined degrees outnumber graduates from the single degree. They also have a positive impact on gender diversity in engineering, e.g. the introduction of combined degrees at the University of Melbourne increased female enrolments in engineering to an all-time high of 28% in 2002 (Shallcross & Wood, 2002). Similarly, data from Lowe et al. (2018b) at the University of Sydney showed that 55.45% of female engineering students complete a combined degree compared to 43.85% of male engineering students. Most notably, female engineering students dominated in combined degrees with Architecture, Arts and Medical Science, while the only engineering combined degree that reported a higher proportion of males was an Engineering/Commerce degree.

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Methodology

In this study, we explore and discuss the current opinions around combined engineering degrees, particularly in terms of the following themes:

- depth vs breadth in engineering degrees
- industry-readiness of combined engineering degree graduates
- integrating the components of the combined engineering degrees

In addition to a review of the literature on combined degrees, we supplement views from existing research with data from University of Sydney participants in the form of academic comments from semi-structured interviews (n=5), as well as current and graduate student comments from an online survey (n=14 combined degree students). Responses included below are labelled A1–5 for the academic comments and S1–14 for student comments. Although a small sample from a single institution, our data nevertheless highlights the gamut of opinions on combined degrees demonstrated in previous literature. The ethical aspects of this study have been approved by the HREC of the University of Sydney 2020/493.

Discussion

Depth vs breadth

Combined degrees offer students breadth of learning and opportunity to build upon a greater variety of skills as they can concurrently complete subjects from two different faculties (Shallcross & Wood, 2002). It can be argued that the non-engineering degree in a combined engineering degree program can greatly benefit the engineering component—and vice versa—and assist in producing graduates with a greater diversity of skills to better meet the diversity of engineering practice as outlined in ACED Engineering Futures 2035 Scoping Study (Crosthwaite, 2019). As also indicated by Crosthwaite (2019), technical skills and competency will continue to be required by the engineers of the future and therefore will continue to be a requirement of the engineering curriculum; however, the question around depth vs breadth that is evident in engineering education more broadly is particularly obvious in the combined degrees.

Moulton (2010) argues that combined degrees can prevent students from achieving sufficient depth in their area of study, making it more difficult for students to continue into postgraduate research. Furthermore, combined degree students may not have the same opportunity to gain generic and critical thinking skills as the subjects and electives that offer this may be removed due to the integrated structure (Moulton, 2010). However, Lever et al. (2011) argues that combined degrees enable further development of transferrable skills such as professional communication, professional values, conduct and judgement and information skills. With engineering degrees often criticised for not adequately teaching students non-technical skills, a second degree appears extremely beneficial (Lever et al., 2011). However, it is important to consider what the non-engineering degree offers:

> *"it very much depends on exactly which options they pick. I don't think it's like combined degrees per se improving skills… the basic accountancy stuff is probably even less engaging than what we do [in engineering]… and if they're doing economics there's probably more chat, discussion and generic kind of skill gain"* [A3]

Similar sentiment was noted amongst the combined degree students, e.g.

> "*a maths degree has the ability to be completed with little to no communication with the remaining cohort*" [S14, Engineering/Science]

> "*I believe the assignments in the business school and my major (finance) are less collaborative by nature because the industry places more emphasis on individual achievement… I believe this 'mindset' hinders the development of professional skills*" [S7, Engineering/Business]

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> "*little to know (sic) group work so teamwork was not learned by many students, culture was not collaborative*" [S10, Engineering/Law]

in comparison to:

> "*there has been a much stronger emphasis on presentations than my engineering degree, encouraging growth in professional communication skills*" [S1, Engineering/Business]
>
> "*most of my subjects revolved around presentations, group activities and seminar-style classes…. Also, the nature of an Arts degree was that I would work with students from across various fields, and it was both interesting and challenging to work within and through different communication styles/thought processes/methods of working- but super applicable in practice*" [S2, Engineering/Arts]
>
> "*written communication skills and [interdisciplinary] effectiveness highly developed*" [S10, Engineering/Law]

This highlights a need to consider the engineering combined degrees as individual degrees, each offering a different approach to the combined degree and thus contributing to the development of potentially quite different aspects of an engineer's professional skills and identity.

There are also concerns that the breadth offered by a combined degree may also lead to cognitive overload, i.e.

> "*a bit of a double edge sword because they are more intense – students need to switch their thinking and learning multiple times a day – whether that impacts their quality of learning overall?*" [A1]

However, Russell et al. (2008) note that some students find the swapping between the two disciplines of a combined degree helpful and believe that it keeps them from being bored with either discipline. The divergence in these two views is perhaps explained by Lowe et al.'s (2018a) findings that, while higher-performing students tend to benefit from broader learning, lower-performing students could struggle with broader learning. In terms of the impact on their engineering capabilities,

> *"For some students they need that narrower focus to perform well enough to be really competent and therefore to be a good engineer… for better students, they can cope with that diversity without losing that strength and then the diversity helps them take the steps beyond that"* [A2]

In addition, it is unclear if combined degree students have better opportunities to develop their professional skills in their non-engineering degree or if their proficiency in their professional skills is what leads them to choose a combined degree, e.g.

> "*the fact that they recognise broader disciplines means that they have that breadth of interest to do a combined degree*" [A2]
>
> "*I think people who do arts degrees are assumed to have the soft skills required for professional settings*" [S6, Engineering/Arts]

Nevertheless, regardless of which degree a student chooses to combine with their engineering degree, the breadth does have value in widening perspectives, e.g.

> *"I think they all help just being exposed to different disciplines with different cultures*" [A2]

This suggests some of the value of a combined degree is in the development of desirable graduate attributes (such as versatility, adaptability, flexibility) that are not necessarily encapsulated in the Engineers Australia Stage 1 Competencies.

Industry-readiness

Fleming et al. (2010) interviewed 30 engineering-focused organisations on their willingness to employ graduates with combined engineering degrees and found mixed employer perspectives. Some employers preferred dual degree engineering graduates for their greater

breadth of knowledge and skills. However, other employers suggested that there was little difference between single degree and combined engineering graduates, and that academic results, engineering skills and industry experience were considered more important than a combined degree.

Fleming et al. (2010) also noted that some employers perceived the completion of a dual degree as an indication of greater academic ability due to higher entry requirements. Lowe et al.'s (2018a) findings also indicate that combined degree students tend to continue their strong performance during their studies at university, with combined degree students at the University of Sydney having an average course mark that was 6 marks higher than the single-degree students over the period 2006–2016. Thus, combined students may be more appealing to employees due to their perceived academic capacity, rather than due to the breadth of their knowledge, i.e.

> "*because the ATAR requirements are higher [for combined degree students], potentially they are more likely to get a job if the criteria for success is based on intelligence*" [A4]

> "*the industry are keen to employ [combined students] because they are smart students so they make excuses for their lack of technical skills and… 'we are going to train them up on the technical side' "* [A3]

Nevertheless, the wider perspective that a combined degree can generate has strong potential to build interdisciplinary effectiveness. This appears to be well-recognised, e.g.

> "*combined degree students tend to realise that there are different ways of seeing the world rather than a single narrow engineering lens… single degree students can think it's all about the engineering and other disciplines don't have much to offer so they don't need to engage with them*" [A2]

> "*combined students are more open-minded and are prone to accept that things can be different and approached differently*" [A5]

> "*there has been a stronger focus on framing organisations from a big picture perspective*" [S1, Engineering/Business]

This is in line with employer perceptions that combined degree students tend to have better generic and broader skills (Fleming et al., 2010). Furthermore, combined students may be better equipped due to their broader knowledge base,

> "*combined degree students might be better just because they have that slightly broader knowledge base to draw on their engineering work if they choose to go into engineering*" [A1]

This agrees with Lawrence (2020) who noted that, even though industry indicate that graduates can learn quite a lot on the job, engineering graduates would benefit from a widening of the broader knowledge base, particularly from complementary areas of expertise such as design.

There is some concern that the lack of engineering electives (technical content and technical depth) that combined degree students complete may have an impact on their readiness for industry, i.e.

> "*combined degree students do not do elective engineering units so you cannot say that they are well equipped for entry into professional engineering… the question really is "are the students actually being equipped for the real challenges of the future?" and the combined degree students, because they're doing less, are less so in my opinion*" [A3]

This echoes Moulton's (2010) concerns around combined degrees preventing sufficient depth for technical competency and should not be dismissed because,

> "*there are some engineering roles where a single degree student may be better equipped because they are so immersed in just engineering so they have built better technical capabilities*" [A2]

Nevertheless, some consider the trade-off between elective engineering units and non-engineering units as acceptable,

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> "*one of the distinctions between single and double degree students is that the single degree students have done that extra three or four electives. I don't think that matters one iota at all… look, they've missed out on some theory. They'll pick it up in five seconds*" [A4]

This appears to reflect Lowe et al.'s (2018a) findings that combined degree students are generally higher-performing students, suggesting they may be better equipped to learn and adapt on the job. This is also in line with Fleming et al.'s (2010) findings that combined degree students may be favourable to employers because of a greater willingness to work outside of their technical areas. This adaptability appears increasingly important, particularly if some graduates find that,

> "*university curriculum is largely irrelevant to what is actually required in the profession*" [S12, Engineering/Business]

There are also indications that, while technical capability may be valued at graduate level, career advancement may be tied to the broader skillsets that combined degrees offer, e.g.

> "*[civil engineering]'s not a career where there's a huge amount of advancement opportunities within the context of being a technical person and the ladder for advancement in the broad construction industry is by branching out into project management, a bit more finance, managerial*" [A4]

This is similar in sentiment to some employees who see the technical capacity as a necessity in the short term but acknowledge that the knowledge and skills from the non-engineering degree could be advantageous later in one's career (Fleming et al., 2010).

Integrating combined engineering degrees

As indicated above, there are a wide range of experiences associated with the combined engineering degrees. It is this diversity of options that makes combined degrees attractive to students but is also ultimately problematic for engineering educators and accreditors in that it creates the need for diversity in the approaches to managing and accrediting them. There has been over a decade of calls to better integrate the two components of the combined degrees (Russell et al., 2008; Moulton, 2011). However, current practice is to focus on only teaching and evaluating the engineering component of the combined degrees. Since the engineering component is regarded as a standalone degree, there is limited interest in learning about other degree components or in recognising their contributions to an engineer's professional capacity. This is highlighted in the fact that,

> "*very few of us have an understanding of what the students do in their second degree at all…all of their science degree and all of their arts degree is elective and so we've got very little understanding of all of that*" [A4]

This stems from the combined degree structure effectively being two degrees run in parallel and, as noted by Russell et al. (2008), this results in an administrative structure, rather than a pedagogical one. This can result in logistical difficulties in elective availability and timetabling, as well as complexity in finding appropriate academic advice, which negatively affect the combined student experience. Although there is some sense of joint ownership, the responsibility often falls to one discipline to administer. For example, at the University of Sydney, the Faculty of Engineering administers most combined engineering degrees, which may suggest that the onus is on engineering educators to drive change in the combined degrees. However, it is ultimately not solely in the hands of engineering educators as refinement and better integration of combined degrees would inevitably require input from educators from both sides of the combined degree.

Until 2021, the engineering component of the combined degrees at the University of Sydney had fewer units than the standalone degree. Changes to the combined degree will bring it closer to the standalone engineering degree and Engineers Australia's accreditation requirements for 3.5 years equivalent of engineering units. How exactly this will affect the combined engineering degree lengths remains to be seen, but it is likely that this will shift towards a model where the length of the degree depends on the non-engineering degree.

This greatly simplifies the accreditation process, but perhaps undermines the attraction of the combined degrees as shorter and more financially viable. It also continues the tradition of treating the two degrees as separate entities, rather than using the opportunity to trial a more cohesive pedagogical framework for the combined degrees. The shift to increasing the number of engineering units has been supported by staff members at the University of Sydney as they believe that these changes will improve the technical depth of the combined degree students. This approach is also in line with academics' perception of the low value attached to risk taking (Reidsema et al., 2021) and the greater number of students impacted by investment of time and resources in changes to the engineering degree—taken by both single degree and combined degree students—over the combined degrees.

Industry has suggested that combined degrees could benefit from courses that link the two components of a combined engineering degree (Lawrence, 2020). Combined capstone or thesis units have been proposed (Moulton, 2011); however, when this was proposed in 2017 at the University of Sydney, discussions identified several concerns. It needs to be acknowledged that:

- some disciplines do not necessarily mesh well
- the overlap may be restrictive on the student's options to choose their project
- staff may not be able to support the project due to a lack of expertise (perceived or otherwise)
- non-engineering staff may not have time and resources to support a student whose capstone enrolment is outside of their faculty

Furthermore, units that engage non-engineering disciplines in engineering units often run into difficulties with longevity due to being sustained by individual staff members, rather than resulting from a wider cultural shift within the faculty staff (Crosthwaite, 2021). Lawrence (2020) also emphasises the need to not rely solely on combined degrees as a mechanism for diversification, but to also collaborate with other disciplines on the future engineering curriculum. Towards this end, combined degrees do highlight the top-down issues around ownership and responsibility (and ultimately student dollars) that will continue to overshadow bottom-up approaches to implementing more diverse curricula.

This also raises the question of whether students themselves would benefit from greater connection or overlap between the two components of a combined degree as greater connection has potential to negatively impact the combined degree student experience. For example, some students may use the non-engineering degree to take a 'break' from engineering (Russell et al., 2008). Also, given that Palmer et al. (2015) have reported that less than half of Australia's recent engineering graduates work in the engineering profession, it is clear that not all combined engineering students plan a career in engineering in the long term and see a combined engineering degree as a way to manage career uncertainty (Shallcross & Wood, 2002). In these cases, units that connect the two degrees may not be desirable. In fact, when Russell et al. (2008) asked a range of combined degree students (although not necessarily from engineering) what was missing from their degree, only 38% indicated integration of the degrees as a concern. This is perhaps reflected in resistance against developing professional skills within the engineering degree from students also studying non-engineering degrees that have a strong focus on transferrable skills development, such as:

> "*I think the uni should just focus on teaching engineering*" [S6, Engineering/Arts]
>
> "*I don't think it's really the university's responsibility to teach this stuff*" [S5, Engineering/Project Management]

This parallels Lawrence's (2020) point that engineering combined degrees often default to "*automatically aligned fields and those which can be viewed as complementing Engineering*" despite the potential to use the non-engineering degree to augment the engineering degree. Furthermore, for some stakeholders, the combined degree graduates "*represent 'a loss to engineering' if they do not practice in the field*" (King, 2008). These views are engineering-

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centric and suggest that we as engineering educators need to keep in mind that, for some students, it is not necessarily the case that the non-engineering degree exists to further the engineering degree, but that the engineering degree exists to further the non-engineering degree. This may be particularly the case at the University of Sydney, where:

> "*the proportion of combined degree students … is higher [than a nearby university in Sydney]. I think that's partly because you are much more likely to come to USyd to do a combined degree because of the second degree being better*" [A2]

and it merits investigation of other institutions in future to establish how dependent on the University of Sydney context these opinions are.

Conclusion

So, where *are* we at with combined engineering degrees? There continues to be the following concerns:

- the debate around the development of depth vs breadth in combined degree graduates, which mirrors the lack of agreement over depth vs breadth in the single engineering degree (as indicated by Crosthwaite, 2021)
- a need to recognise graduate attributes that are developed through breadth of study (e.g. versatility, adaptability, flexibility)—and are increasingly required by engineering graduates—in the Engineers Australia Stage 1 Competencies
- a need for greater recognition that, although engineering graduates may not immediately benefit from a combined degree, there are great benefits for their long-term careers and for the discipline overall
- the segregation and siloing of the two components of a combined engineering degree, which will require a top-down approach from Engineers Australia accreditors and teaching & learning leadership
- concerns with the workloads in creating cross-disciplinary units, as well as the longevity of such units, which will require investment and long-term support from teaching & learning leadership
- a lack of clarity around the impact of integration of the two components of the combined engineering degrees upon the student experience and how students might react to this, which could be addressed by future research

In this paper, we have highlighted the key issues currently associated with the engineering combined degrees, demonstrating that there is still much that can be done to improve combined engineering degree offerings. Given that engineering faculties reap significant benefits from offering combined degrees—such as higher enrolments, attracting students that are higher-performing or from more diverse backgrounds—opportunities to improve combined degree offerings should, at the very least, be reviewed by faculties.

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