Engineering Futures 2035

A Survey of Australian Engineering Academic Attitudes and Capabilities for Educational Change

for the

Australian Council of Engineering Deans

(ACED)

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Dr Carl Reidsema

Dr Ian Cameron

Dr Roger Hadgraft

Summary

Recommendation 3: Engineering Educators (Task 1 - Survey)

Establish the existing engineering educator workforce profiles that can deliver on the forecast 2035 knowledge, skills and attributes by undertaking a survey of the existing engineering educator workforce, to analyse their knowledge, skills and attributes.

This report highlights the approach taken to survey academic staff within Engineering Faculties in Australia to further the understanding of the Australian Council of Engineering Deans (ACED) of academic workforce capabilities and readiness for the major curriculum reforms proposed in the 2035 Engineering Futures report.

The survey explored academic beliefs regarding seven factors identified by the 2035 Futures report as critical for future success:

1. making change in teaching practice,
2. integrating real world situations,
3. using digital technologies,
4. increasing industry collaboration,
5. integrating human/social dimensions,
6. using e-learning, and
7. ensuring professional development for engineering educators.

Teaching and learning strategies

Engineering academics[1] expressed the strongest belief in the importance and effectiveness of the following teaching strategies for achieving the 2035 graduate capabilities:

- ‘e-Learning’ (90% agreement[2]),
- ‘Using Real World Integration in my teaching’ (87% agreement), and
- ‘Collaboration with industry’ (82% agreement).

This finding was supported by an Exploratory Factor Analysis (EFA) that showed that there were two significant factors predicting an ‘Intention to change my teaching’:

- Importance of e-Learning: r^2=32%
- Importance and effectiveness of Real-world and industry collaboration: r^2=21%

Confidence, perceptions, and intentions

Academic staff are highly confident[3] in their abilities to either adopt or facilitate these strategies (avg. 90%). Their perceptions of leadership expectations to adopt these strategies align well, with the exception of using real world integration in their teaching with only 55% agreeing. However, with the exception of ‘e-Learning’ at 89% agreement, academics do not express equally strong intentions to adopt or increase their efforts in these directions over the next year or two (avg. 70%).

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[1] Demographic overview: Data from 372 Respondents, 36 Institutions, 16 Disciplines (8 > 3.6%)
[2] ‘% Agreement’ defined as % responses who ‘Completely – Slightly Agree’ on a scale of 1 - 4
[3] It is noted here that confidence is not the same as capability.

In terms of researching Teaching and Learning (T&L) practices to support and underpin their professional practice:

- 89% agreed that it was important to be aware of global best practice, and
- 87% agreed with the importance of investigating global best practice.

These high levels of agreement of importance did not match with their stated intentions in the immediate future (the next year or two):

- 64% of respondents intended to spend more time developing their engineering educator role but only 40% were intending to pursue promotion based on T&L,
- 57% intended to commit more time to investigating global trends in engineering education,
- 42% intended to attend an engineering education conference, and
- 25% of respondents indicated that they did not use educational literature to guide changes in teaching.

Motivations and attitude to change

Academics in T&L leadership positions (Associate Deans (T&L), Heads of Schools, and Heads of Departments) have a more positive perception of institutional support and rewards than those not in T&L leadership positions for all five surveyed T&L strategies (points 2-6 above). This is despite the analysis suggesting institutional rewards and support were not a significant factor in T&L change.

When it comes to changing their teaching, engineering academics believe that incremental changes are more effective than rapid changes (76% agreement). In addition, while academics agree that learning how to take risks in T&L practice is important (84%), they believe that ‘managing risk’ (89%) is more important in T&L leadership. Taking risks in communicating innovative pitches to T&L leadership is perceived as less than welcome.

Responses to the survey showed that academics are more likely to emulate their peers (60/20% agree/disagree) than their T&L leaders (50/30% agree/disagree).

Barriers to change

The most significant reported barriers to innovating within the role of engineering educator were identified as “Time taken away from research” (35%) and “Lack of available funding” (26%). Interestingly, “Student Satisfaction” (13%) and “Impact on Promotion” (11%) were not so important.

Additionally, barriers to integrating non-engineering bodies of knowledge into the curriculum are primarily constrained by ‘Available Time’ (43.8%) and Lack of expertise’ (18%) which may indicate that a strategy that seeks to broaden the existing curriculum is contingent on the provision of external support.

What do the responses mean?

T&L strategies

- For *e-Learning*, its importance/effectiveness and intentions are high due to COVID-19 forced changes
- There is good recognition of the importance of evidence-based pedagogies for effective engineering education, particularly using real world issues in teaching and collaborating with industry. This may be a flow-on from a greater emphasis on industry-relevant research in recent times.

Confidence, intentions, and cultural perceptions

- Academics are, for the most part, aware of the need to keep up to date in the fast-changing world of higher education.
- However, a change in mindset is required to encourage academics to act and develop the effective habits of an engineering educator role that incorporates scholarship of T&L.
- The low perception of institutional rewards and support is likely due to a number of reasons, including workloads, recent COVID-19 T&L budget cuts, and the lack of recognised research funding for T&L innovation.
- Academic beliefs that T&L Leaders have low expectations for integrating human and social issues into the curriculum has implications for developing T-shaped engineering graduates.

Motivations and attitudes to change

- A transformational change narrative is unlikely to be well received by a workforce with a preference for incremental and risk managed T&L change, particularly in the current environment.
- Academic perceptions that leadership are unreceptive to communicating innovative T&L ideas could inhibit internal creative responses to future change.
- Peer influences appear both as positive (discipline champions) and negative (resistance to leadership in challenging times).

Barriers to change

- The common models for academic roles (e.g., 40% research, 40% teaching, and 20% service), and motivations for disciplinary research) work against T&L innovation.
- Although T&L innovation has predominantly become student-centred, it is not primarily motivated by student satisfaction.
- The perceived low value of risk taking and professionally developing as an engineering educator do not lend themselves to achieving the 2035 objectives.

Summary

Overall, the survey provides a positive picture of engineering education in Australia, with academics aware of and willing to engage with change in their T&L practices. However, these same academics could be perceived to still be working strategically, only engaging with T&L change within the context of their careers and interests.

Commentary

Historically, changing the way we educate engineers has been a slow, incremental struggle with occasional sustainable innovation at limited scale. However, the externally imposed threat of COVID-19 (i.e., the need to switch to emergency remote teaching), revealed a systemic buy-in to e-Learning that could be leveraged by engineering leaders to initiate a long-term and sustainable renewal of their programs with a workforce capable of delivering the 2035 graduate capabilities. Indeed, academics demonstrated remarkable flexibility and willingness to implement transformative changes in the way that they work and in their approaches to teaching through the COVID-19 experience.

This implies that the direction forward should be towards necessitating and developing engineering education capabilities, leveraged by digital technology and located at the intersections of academia, industry, and the community.

In addition, whilst academics are confident in their abilities to adopt future teaching strategies and are aware that a scholarly body of work exists along with opportunities to join communities of practice, they are not necessarily aware of recent developments in teaching their topic areas. Therefore, strategies must be developed and implemented to increase their intentions to engage in change in line with global best practices.

What might we do?

Firstly, we should capitalise on the opportunities that COVID-19 has brought to our practice and practices (i.e., rapid change and innovation, a re-consideration of the value of formal lectures, and the adoption of effective technology).

Academics have shown knowledge of education innovation, and confidence in engaging with change, albeit in an incrementally managed fashion. What is needed is a further push by those in leadership positions towards addressing the issues of risk mitigation and professional development as they relate to T&L change.

If a national response was coordinated and shared by ACED, it would have the additional effect of reinforcing T&L leadership's openness to, and acceptance of change.

Forming coalitions of willing partners, either involving multiple institutions or multiple disciplines within one institution, to implement one or more of the exemplars identified in the Stage 2 report on curriculum and pedagogic approaches, modified to local circumstances, is required. Local teams must be led by senior leaders who will act as project sponsors. This project leadership will help to mitigate the risk perception of academic change. Augmenting these teams with industry representatives and engineering pedagogic expertise will be vital.

The further expansion of institutional role models and identification of change agents in T&L will help ACED communicate the continued importance and support for T&L change nationwide.

Recommendations

1. *Develop **pilot projects** for innovative curriculum initiatives that require industry practitioners to collaborate with engineering academics on creating and delivering authentic real-world learning experiences.*
2. *These pilot projects should build on the use of **online/digital technologies** to connect and develop relationships between industry practitioners and T&L academics responsible for designing the new curriculum.*
3. *Identify and support both '**change' and 'boundary' agents** willing and able to be involved in the proposed pilot projects*
4. *Conduct a national review of initiatives that encourage **development, rewards and promotion** for T&L staff.*
5. *Develop a roadmap for implementing a national program for **Continuing Professional Development** (CPD) to build academic teaching capability*

Future Action

To effect these changes, an **ACED steering group** should be commissioned to oversee the recruitment of change agents, identify and formulate pilot projects, and develop a roadmap and process for **Continuing Professional Development** (CPD). **Industry and government representation** should be sought for both the steering group and for the CPD development.

These pilot projects would establish commitment and capability to underpin a proposal for 2022 **Strategic University Reform Funding** (SURF), to be developed and submitted by Feb 2022. Such a proposal needs to align with government priorities, such as industry transformation and higher education transformation.

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1 Background

There is a rich chronology of national (Crosthwaite, 2019; Engineers Australia, 1996; King, 2008) and international reviews (National Academy of Engineering, 2004, 2005; Sheppard, Macatangay, Colby, & Sullivan, 2008; Spinks, Silburn, & Birchall, 2006) of engineering education extending over the past 100 years that persistently emphasises the need to balance engineering science with engineering practice. Change in this direction over time appears to be a slow, and often an incremental struggle with few sustainable major innovations.

At present, large institutions face serious challenges in expanding and scaling authentic practice-oriented student learning. Where solutions combining practice at scale have been attempted, new and more complex challenges have surfaced. Authentic, practice-oriented curriculum face real challenges in achieving cost efficiencies.

Adequate educational-workforce capabilities are another issue, where large group facilitation skills are required. A reward structure is needed that will encourage academic staff towards ongoing professional development and engagement with industry practice.

Adding further complexity, the COVID-19 pandemic has seen enormous workforce efforts to switch to online e-Learning and efforts to adapt traditional curriculum practices in the face of the need for remote learning. This immediate crisis leaves many Schools of Engineering at risk of not being able to see the vast range opportunities that this disruption to 'business as usual' can provide.

The Engineering Futures 2035 Stage 1 Report which pre-dates the COVID-19 pandemic, warned that urgent action was needed and indicated the potential directions that Australian Schools of Engineering should consider in delivering the graduate capabilities for the anticipated changing nature of engineering work in Australia in the year 2035. These included a:

1. more *humanized and societal* focus in engineering education programs,
2. better '*real-world'* integrated curricula, delivering a broader range of outcomes,
3. stronger focus on *complexity* through *systems thinking* and *design*,
4. significantly stronger emphasis on *digitalization* and the impact of Big Data, and
5. stronger *external engagement* with *industry* and the *community* in teaching.

One of the major conclusions of the report was that:

"Changing curricula, pedagogies and new kinds of engineering educators will also be needed."

The report made three recommendations for further detailed investigations during Stage 2 (Crosthwaite, 2019). This paper concerns itself with the survey results from Recommendation 3 (Engineering Educators). The aim was to establish both the existing engineering educator workforce profile and a desired profile that can better deliver on the above 2035 outcomes. This national 'survey of the current engineering educator workforce' sets out to better understand academic readiness for major change in teaching engineering.

1.1 Project Brief

The Engineering Futures 2035 scoping study explored the knowledge, skills and attributes of professional engineers required to meet anticipated changes in the nature of engineering work in Australia in the year 2035. It explored potential approaches to engineering education that prepares graduates and made 3 major recommendations for further immediate detailed investigation. This project concerns itself with **Recommendation 3: Engineering Educators (R3)** which identified three (3) major tasks:

1. Establish the existing engineering educator workforce profiles and desired profile for the engineering educator workforce that can deliver on the required knowledge, skills and attributes by:
   a. Undertaking a survey of the existing engineering educator workforce, to analyse their knowledge, skills and attributes, and
   b. Performing a gap analysis against that required to effect curriculum and pedagogic renewal in future engineering education programs.
2. Undertake a desktop review of models that may be used to successfully facilitate engagement of engineering educators with a broader range of experience in engineering practice outside academic environments. This includes practitioners who can engage with students in innovation, entrepreneurship, and design focused learning activities and assessments.
3. Propose solutions to modify the engineering educator workforce as indicated by the gap analysis and informed by the desktop review.

2 Methodology

2.1 Overall survey plan

Figure 1 shows the overall activities that were undertaken as a basis for the work.

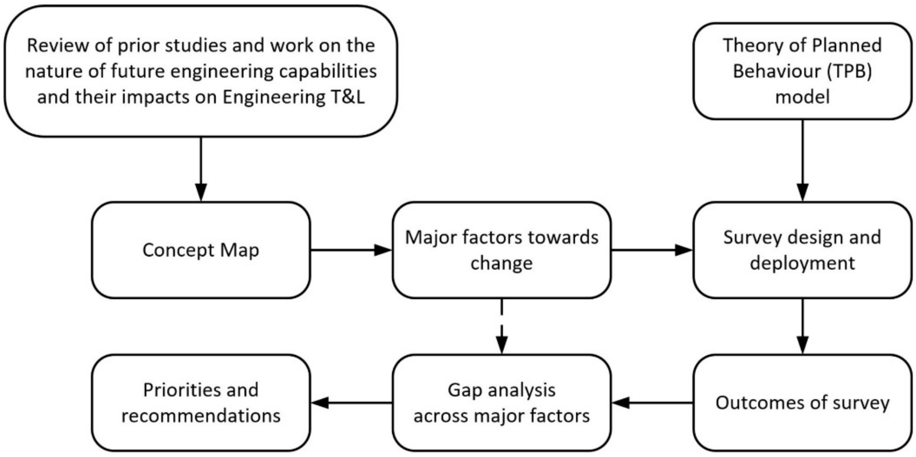

Figure 1: Overall work plan

The major steps were:

1. A substantial review of previous work related to engineering graduate capabilities to meet future professional requirements in a rapidly changing global environment. This included the recent work by Crosthwaite (2019) related to the Scoping Study for Engineering Futures 2035.

2. The development of a concept map that captured key concepts and their interrelations. This is seen in Appendix A.

3. The concept map was used to identify the key areas that would be crucial to drive change, thus identifying the major factors to be considered.

4. The well-regarded Theory of Planned Behaviour (TPB) was adopted as a framework to guide the design of the survey (Appendix E). This survey was designed using the on-line Qualtrics package (Qualtrics, 2020).

5. Outcomes of the survey were collated and analysed within the Qualtrics environment as well as using external packages such as Excel, JASP (2020), R (2020) and RStudio (2020).

6. Insights around possible gaps in attitudes and intentions towards T&L change related to the major factors were then considered.

7. Finally, a summary of major insights and recommendations were developed as a set of outcomes from the work.

2.2 Theory of Planned Behaviour (TPB)

This new survey instrument, which seeks to understand engineering academics' perceived readiness for change, has been built upon the Theory of Planned Behaviour (TPB) (Ajzen & Madden, 1986). It emphasises beliefs, norms, and control (Figure 2), as the basis for *intention to change behaviour*.

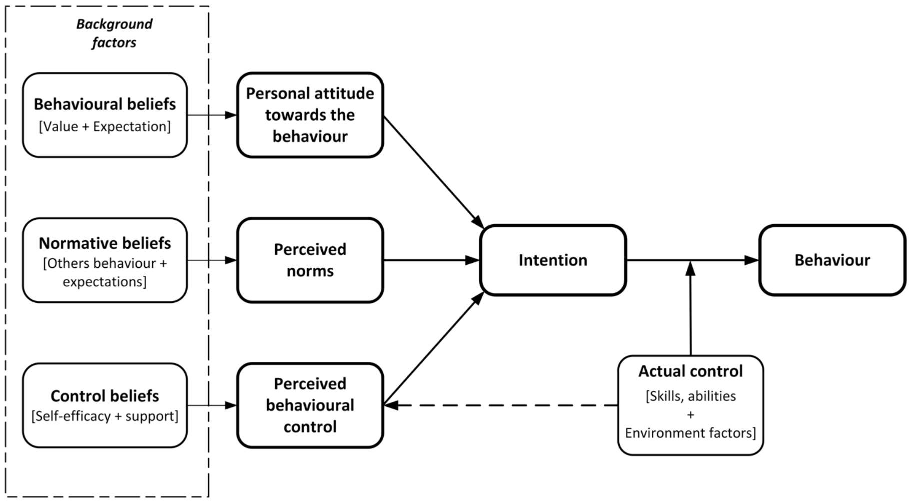

Figure 2: Elements in the Theory of Planned Behaviour

Background individual, social and informational factors influence *behavioural beliefs* regarding the *value* and personal *expectations* of enacting a *behaviour* (top left bubble). These beliefs shape personal attitudes towards one's intention to enact the behaviour.

Normative beliefs (middle left bubble) arise from the individual's perceptions of social pressures and willingness to comply, while control beliefs (bottom left bubble) focus on the individual's perception about their personal abilities and external factors that help or impede attempts to carry out the behaviour. *Do I believe I can make this happen and what support is available to help me?*

The TPB model also recognises that 'actual' control can be dictated by factors completely outside the influence of the individual, despite 'their best intentions'. The TPB model was used to help formulate the structure of the separate statements within each theme of the survey instrument. This ensured that the principal TPB elements were represented in the survey statements.

2.3 Survey Design

The design of the engineering academic survey began in late March 2020 with an extensive literature review of key factors within educational change followed by an equally extensive concept mapping process conducted by the project team. This resulted in a set of key factors (Appendix E) around which the survey could be formulated, including:

1. The process of change itself, that must underly any constructive response towards delivering a future (2035) curriculum,

2. five (5) factors of teaching change considered most likely to lead to the desired capabilities of future engineering graduates (Crosthwaite, 2019), and

3. the respondent's disposition towards their professional development as an engineering educator.

The curriculum change that is most likely to deliver the broad range of future graduate capabilities is one where 'professional engineering practice' plays a more prominent role. This practice is best developed in collaboration with industry and the community. This provides for contextual relevance by allowing learning to take place in authentic spaces, which may be on location 'off-campus' or through increasing the 'on-campus' integration of real-world as well as human/social issues. This necessitates an appreciation of relevant non-engineering bodies of knowledge as well as a context that focuses more highly on 'real-world' problems.

A focus on 'real-world' problems in authentic contexts allows for the widest range of learning outcomes that span from simple awareness to the deeper learning that is inherent in the complexity of the real-world. This suggests the aggregation of complex problem solving with design, requiring a high degree of contextual awareness, underpinned by the need for horizon scanning and innovation or lateral thinking. More creative/innovative capabilities require a willingness to take risks that may challenge social norms, an ability to persuade others and be able to pitch innovative ideas to organisational leadership. It includes curiosity and awareness of global issues as well as non-engineering knowledge that contributes to the problem's context.

While the 2035 report emphasised a shift in graduate capabilities towards digitalisation and an understanding of the concepts of Big Data and all that implies, we assume that any major shifts in the knowledge or topic level focus within Faculties are likely to only occur through the development of research strengths in these areas. We found it more feasible to focus on the factor of using "digital technologies to model problems" as a pathway to establishing the relevance of a data driven mindset to students through modelling of engineering problems using digital technologies.

The initiation of this project also coincided with Australian Engineering Faculties retooling their programs to be completely online due to the COVID-19 pandemic. This highlighted the need to address a longstanding question regarding the beliefs and abilities of the academic workforce towards the role of e-Learning in delivering the graduate capabilities. The capabilities outlined in the 2035 report, address both the breadth and depth of Engineers Australia's (EA) Stage 1 Competency Categories of PE1: Knowledge and Skill Base, PE2: Application Ability, and PE3: Professional and Personal Attributes.

Finally, we assume that Professional Development in Engineering Education is a critical enabling factor required to drive the pedagogical changes needed to achieve future graduate capabilities.

2.4 Structure

We identified seven (7) different change categories aligned to the potential academic capabilities that will be needed in order to deliver the future graduate capabilities outlined in the 2035 Futures Report:

1. Change in teaching practice.
2. Integrating real world situations in teaching.
3. Using digital technologies to model engineering problems.
4. Increasing industry collaboration.
5. Integrating human/social dimensions within technical contexts.
6. Using e-Learning to deliver future graduate capabilities.
7. Professional development as an engineering educator.

Within each of the seven (7) categories, statements were designed against each of the four (4) dimensions of the TPB model to gauge the respondent's:

1. Perception of their own beliefs and attitudes **(AB)**,
2. perceptions of the norms (attitudes and observed behaviours) of other academics who are either in a local position of leadership or who are within a group of 'important others' such as their peer group **(PN)**,
3. perceptions of self-efficacy towards a particular behaviour along with any perceived constraints on their freedom (autonomy) to act **(PBC)**, and
4. the strength of their intentions to act or engage in these changes **(I)**.

For example, in the area of 'Using real-world situations in my teaching', statements included:

- 'It is important that I increase my use of real-world situations in my teaching' (*value*)
- 'I am confident that increasing the use of current real-world situations in my teaching will produce improved graduate capabilities' (*expectation*)
- 'My leadership team thinks that I should increase the use of current real-world situations in my teaching' (*subjective norm*)
- 'Many of my academic peers strongly support the use of current real-world situations in teaching' (*subjective norm*)
- 'I am confident in my abilities to integrate current real-world situations in my teaching' (*self-efficacy/control*)
- 'I am provided the necessary support to develop off-campus student learning experiences' (*external support*)
- 'I intend to increase my use of current real-world situations in my teaching in the next year' (*intention*)

In order to design these statements, we had to make a number of assumptions, not limited to the following:

1. It is not technical expertise that is of primary importance in our evaluation of the engineering academic workforce capabilities profile. Rather, we view an academic's perceived abilities in engaging in 'learning mechanisms' that are likely to deliver a maximal set of those future graduate capabilities highlighted in the 2035 report.

2. An 'ability' (perceived self-efficacy) is distinct from a 'capability'. A capability is thus defined as an ability with a high degree of autonomy which is uninhibited by perceived constraints, whether they be normative or externally imposed by the environment. For example, we would argue that an academic who perceives they are more than 'able' to engage with industry in their teaching is not inherently 'capable' if their local culture is perceived to frown on this as an appropriate use of their time.

3. Authentic learning such as 'off-campus' learning, 'real-world' problem solving, or 'entrepreneurial design' is viewed as inherently 'riskier' and requires a higher degree of 'persuasive' skills than that involved in traditional curricula.

4. e-Learning (online learning) will play an increasingly important role in the delivery of student learning

For each statement, respondents were asked to rate the strength of their agreement or disagreement on a 9-point Likert scale ranging from 'Completely agree = 1 to Completely disagree = 9', as seen in Figure 3.

	Completely agree	Strongly agree	Agree	Somewhat agree	Undecided	Somewhat disagree	Disagree	Strongly disagree	Completely disagree
Substantial changes to the way I teach in the future will be necessary	◉	○	○	○	○	○	○	○	○

Figure 3: 9-point Likert scale used within the survey

3 Outcomes and commentary

3.1 Demographics

There were 36 Faculties surveyed using The University of Queensland's "Qualtrics Survey" enterprise software, with all Faculties having made at least one (1) successful survey completion. The total number of "Finished" (mostly completed) surveys was (N = 372) out of 511 attempts. In addition, there were 15 "Partial" completions (referred to as 'Missing' by Qualtrics). However, in some cases where respondents completed more than just the 'Demographic' questions at the start of the survey, their responses were included such that the total number of responses (the N value) may vary from N = 372 (+20/-6).

Faculties were sorted into three (3) "Types":

1. Large Research University (LRU) – Faculties whose institution identifies as a "Leading Research Intensive" university (mostly Go8)

2. Metropolitan (METRO) – Faculties whose institution resides within an Australian Capital City

3. Regional (REGIONAL) – Faculties whose institution resides primarily outside the Capital Cities

Table 1 shows the summary statistics for completion rates across the three (3) types of institutions.

Table 1: Completion and contribution rates by Faculty[4] type

Type	Attempts	Finished	Incomplete	Average	
				% Finished	% Contribution
LRU	200	143	57	71.5	39.2
METRO	169	121	48	71.6	33.1
REGIONAL	142	113	29	79.5	27.7

The average contribution rate of these three types of Faculties was 33% with the LRU's contribution rate at 6% above the mean. REGIONAL Faculties were slightly (5%) below the mean. While Regional faculties had a slightly lower number of "Finished" surveys (113) they had the highest percentage of finished surveys at 80%.

For the purpose of further analysis, we set the minimum contribution rate at 2% (at least 9 Completed Responses per Faculty) for inclusion in our final subset, to ensure a fair

[4] For more Detailed Faculty Survey Contribution data see (Appendix B)

representation of responses per Faculty. This results in N=318 completed surveys, which is a statistically significant sample (0.95, 0.05) of the original set of N = 372.

Additionally, N = 318 is very nearly a (0.95, 0.05) sample (requires 326), representative of the 2019 reported Australian Engineering Academic Staff numbers in Teaching Only plus Teaching and Research positions. This is argued on the basis that 92% of survey responders were in Full-Time positions with 4% Part-Time and 4% Casual.

In Figure 4 we see that the highest numbers (95, 93, 98) of respondents who completed the survey were in Full-Time positions across the age ranges of (31-40, 41-50, 51-60) respectively. There were three times the number of over 61-year-old respondents than there were those between the ages of 20-30 (10%).

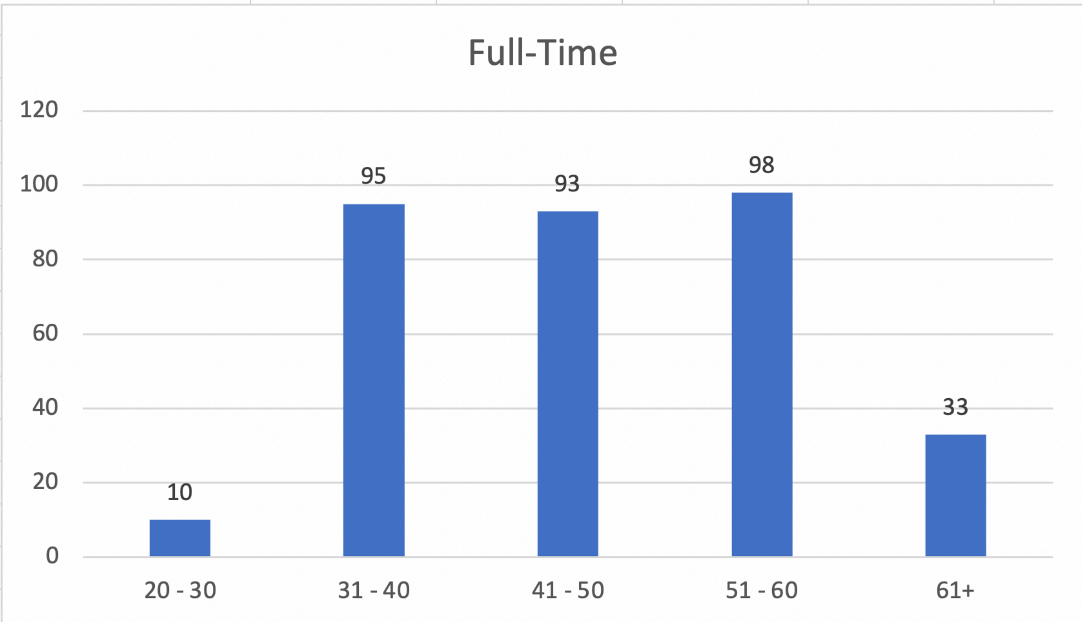

Figure 4: Age Distribution by Full-Time Positions

The overall completion rate for the survey was 57%, with the highest contribution (78%) coming from those in the 51-60 year-old age range and the lowest (60.8%) from those in the 20-30 year-old age range.

There were 75% male and 20% female respondents with 5% preferring not to say.

By far, the largest number of responses by discipline (Figure 5) is attributed to Civil Engineering (87) followed by Mechanical (59) and Electronic, Computer & Telecommunications (ECT (51).

3.1.1 Roles

Approximately 80% of the responses were from Rank-and-File Academic Roles ranging from Lecturer (Level A) to Professor (Level E). As can be seen in Figure 6, the lowest response numbers for the Rank-and-File cohort came from the Associate Professor (Level D) role (66).

The total Rank-and-File response count is 317, which accounts for approximately 85% of the complete dataset of N=372.

For the purpose of this survey, ‘Local Leadership’ is defined as academics who play a line-management of teaching and learning role within a School, Department or Faculty. Whilst there were several roles not defined by the survey (Deputy Dean, Director and Emeritus), the total numbers were deemed inconsequential (< 4). The total number of responses used for the ‘Leadership’ category in the Descriptive Analysis section of this report is thus 39 (-3/+0) responses.

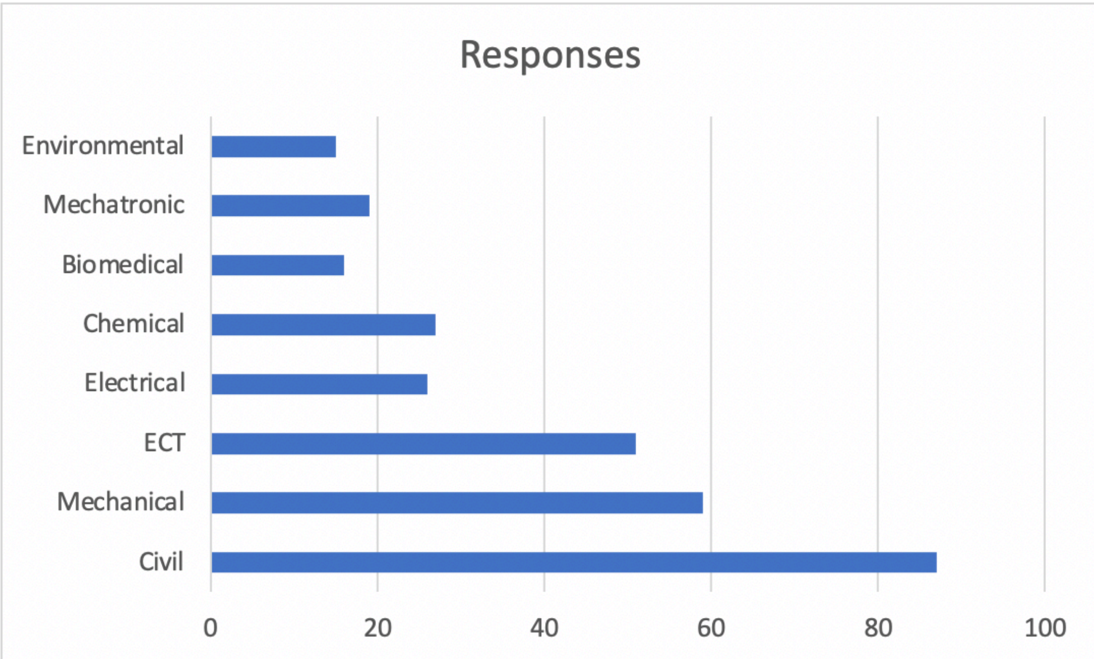

Figure 5: Response by Discipline

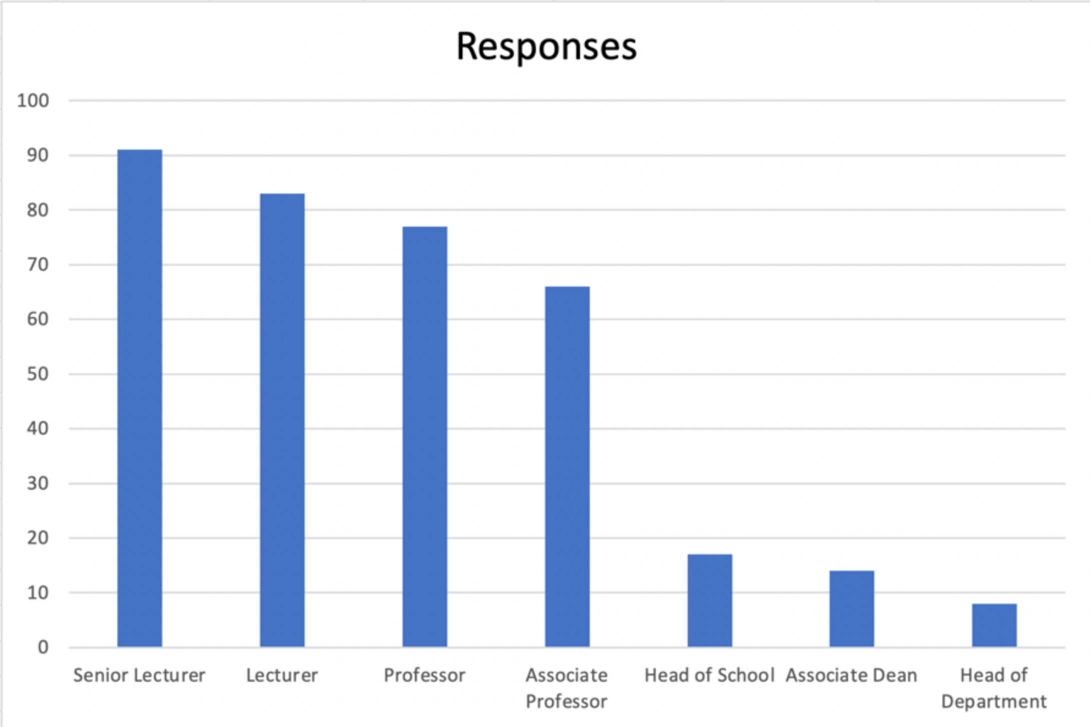

Figure 6: Responses from all Roles

3.1.2 Mode of teaching

While we do not have data from previous surveys regarding engineering academic teaching distributions by “Mode of Teaching” (Figure 7), it is noticeable that the largest contribution (nearly half of all respondents) consisted of academics who reported their mode of teaching to be “Somewhere in between” (43.6%) either “Primarily Face-to-Face” (33.9%) and “Primarily Online (22.5%). We might consider this result to be an indication of the growth of a “Blended” mode of teaching. In the experience of the authors, these percentages would have been significantly different (< 10%) less than 10 years ago, and non-existent 15 years ago.

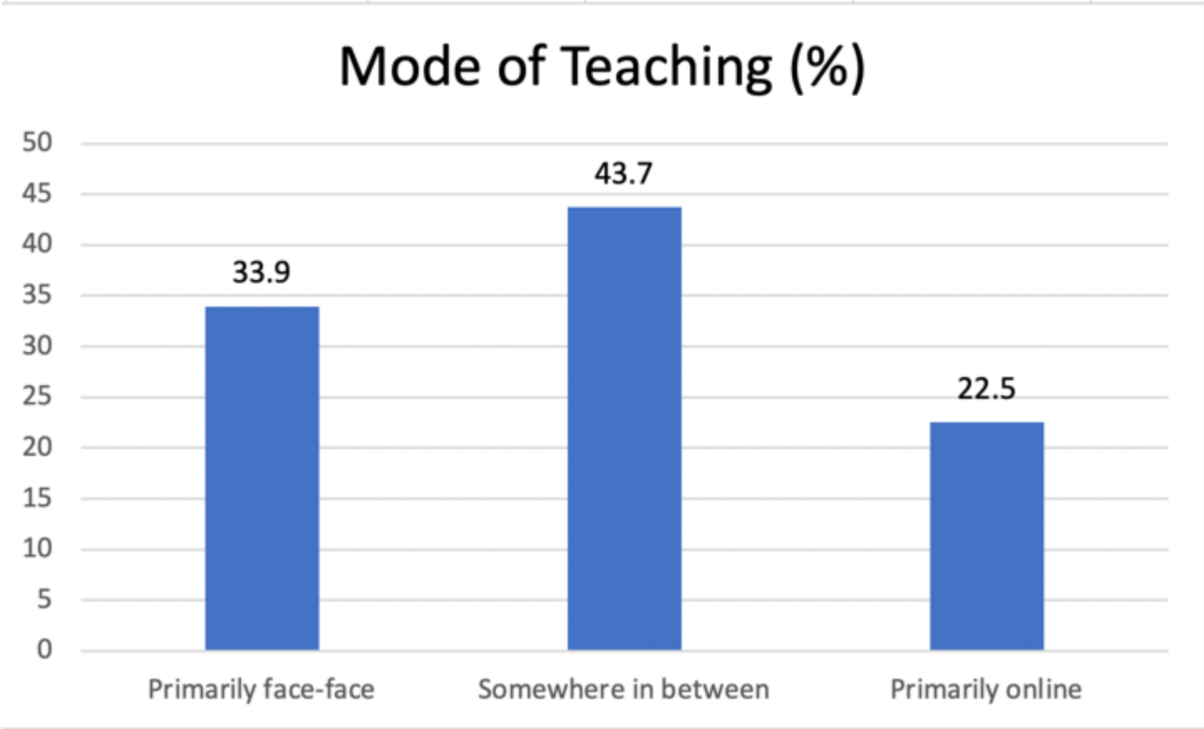

Figure 7: Mode of teaching

3.1.3 Primary teaching area

Respondents were asked to categorise their teaching into one of four (4) possible areas as shown in Figure 8. It may be inferred that “Engineering Fundamentals” are located in the early years of a program whereas, “Advanced Technical Topics” occur later in the degree. Both areas are roughly equal (33% vs 37% respectively), and combined, account for nearly (70%) of all respondents. The remaining (30%) consist of either “Design Projects” (17.6%) or “Management/Engineering Practice” (12.5%).

There were 20 respondents who identified in the area of “Other” as shown in Figure 9. Of these, about five (5) claimed to teach across all areas, and an equal number felt that Computing or Programming did not fit the classifications offered.

3.1.4 Preferred Academic Role

The responses shown in Figure 10 indicate that ‘Teaching and Research’ dominates (76%) an academic’s preferred role, with ‘Teaching Only’ (17%) and ‘Research Only’ role (7%).

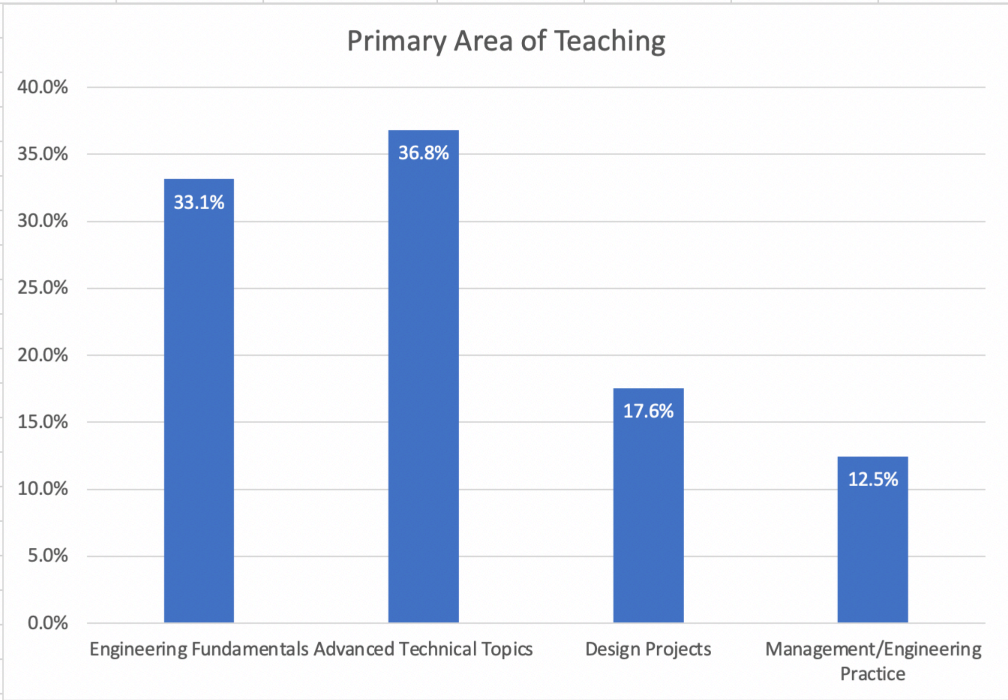

Figure 8: Primary Area of Teaching

Figure 9: 'Other' areas of teaching

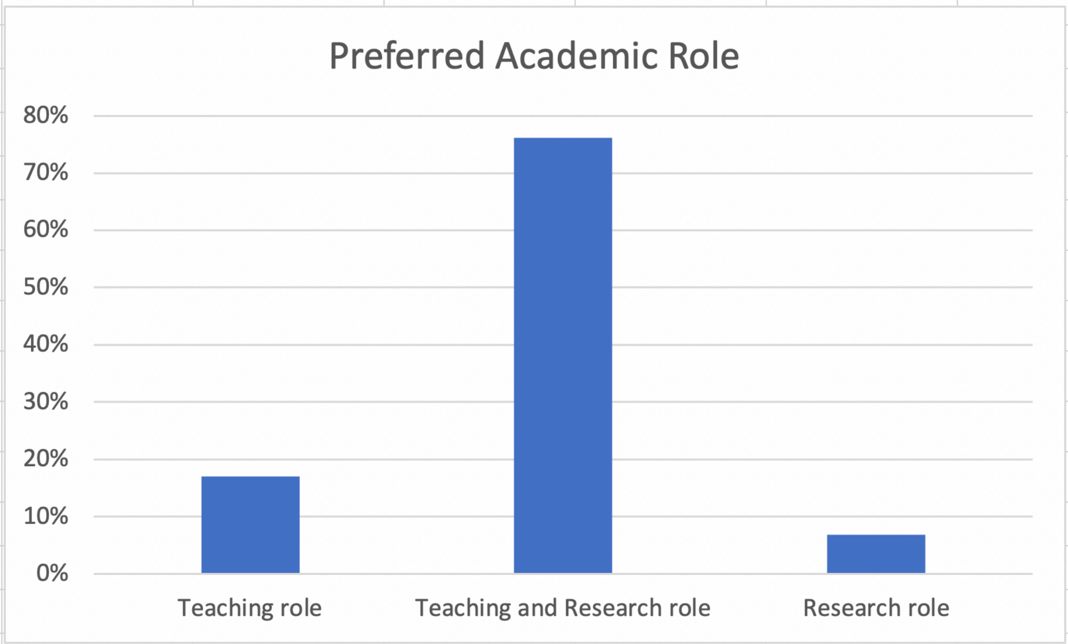

Figure 10: My Preferred Academic Role

3.2 Descriptive analysis

Table 2 summarises the percent (%) agreed responses, the sum of Completely Agree = 1 to Somewhat Agree = 4.

Table 2: Percentage (%) Agreement across all factors

Issue	Substantial Change	Real-World	Industry Collaboration	eLearning	Human Social	Digital Technologies
Importance	78	87	82	90	74	79
Confidence	89	94	86	96	80	85
Leadership	65	57	73	89	55	69
Support	65	44	49	69	NA	57
Rewards	45	NA	49	49	NA	47

3.2.1 Importance of investing more time/effort

In general, academics agree quite strongly with the ‘Importance’ of Substantial Change (78%) and in the importance of investing more time and effort into each of the 5 strategies for achieving future graduate capabilities. Strongest agreement occurs in relation to the importance of investing in e-Learning (90%) and the role that this will play in delivering future graduate capabilities, followed closely by ‘Integrating Real-World Issues” in teaching (87%). The areas of least importance were considered to be ‘Integrating Human and Social Issues” with technical knowledge in teaching (74%) followed by the necessity for substantial changes to teaching (78%).

3.2.2 Confidence in their abilities

Across all dimensions, academics expressed a very high degree of confidence in their abilities to carry out all of the five (5) proposed strategies for delivering future graduate capabilities. The highest level of confidence (96%) expressed was towards their ability to adopt ‘e-Learning’ in their teaching. The lowest agreement (80%) was in regard to ‘Integrating Human and Social Issues” with technical knowledge in their teaching.

While the overall percentage ‘disagreement’ was not particularly strong, the highest disagreement (least confidence) was still marked in relation to ‘Integrating Human/Social’ (10%) and ‘Collaborating with Industry’ (9%).

3.2.3 Local norms (Leadership)

Academics perceive their ‘Leadership’ to have the highest expectations to expend effort in the areas of ‘e-Learning’ (89%) with virtually no disagreement (4%). The two roughly equal and weakest areas of agreement appear to be in regard to expending effort in ‘Integrating Real-World Issues’ in teaching (57%) and ‘Integrating Human and Social Issues” with technical knowledge in teaching (55%). While these two areas also have strong disagreement (14 and 20% respectively), the perception that their leadership demonstrates teaching practices that are change oriented attracts a rather strong disagreement (20%).

3.2.4 Institutional support and rewards

The survey responses appear to reflect an institutional message[5] that is strong on expectations to adopt more e-Learning (85%), moderate on perceptions of support for e-Learning (66%) and weak on rewards for improving the effectiveness of e-Learning (47%).

The quite high level of agreement that leadership expect academics to increase their adoption of e-Learning most likely reflects academic perceptions that have been highly sensitised by the COVID-19 pandemic changes, over the period that the survey was implemented (August – November 2020). A similar gap exists between perceived support (63%) and perceived rewards (44%) for making changes to one’s teaching.

Expectations of support and rewards for important T&L strategies necessary to address professional practice graduate capabilities identified in the 2035 report were similarly low:

- 47% I receive support for collaborating with industry on professional practice learning
- 47% Institution rewards me for engaging with industry for professional practice learning
- 42% I receive support for off-campus learning
- 44% Institution rewards for Digital tools to model engineering problems.
- 40% intend to pursue promotion on T&L in the next 2 years.

[5] Unless otherwise stipulated, leadership expectations are likely to be consistent with institutional messaging

3.2.5 Perceived Barriers

Within the survey, responses were sought to identify specific 'Perceived Behavioural Controls' (PBCs) that may inhibit an academic's autonomy to act. Whilst many barriers could have been explored, we limited ourselves to two areas considered important to 1.) broadening the curriculum, and 2.) creating change in a T&L academic role. The two (2) survey questions implemented to identify the cohort's perceived barriers were:

Q24 - The most important barrier to integrating human and social dimensions with technical knowledge into my teaching would be:

Q30 - The two most important barriers for me to innovate within my role as an engineering educator are:

For Q24, academics were provided seven (7) options and asked to select one (1) which they perceived to be the most important barrier:

The results (Figure 11) suggest an acknowledgement of the inherent complexity involved in broadening existing technical units/courses to accommodate non-engineering bodies of knowledge which are primarily constrained by 'Available Time' (43.8%) and Lack of expertise' (18%). The lower identified barriers of 'Funding (16%) and 'Student Satisfaction (10%) may indicate that a strategy that seeks to broaden the existing curriculum is contingent on the provision of external support.

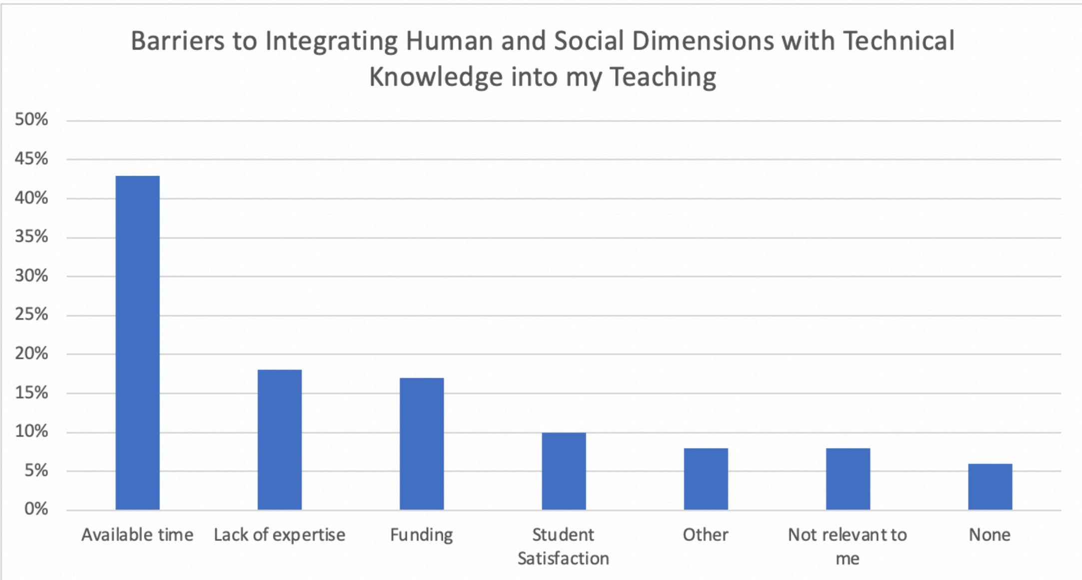

Figure 11: Most Important barrier to Integrating Human and Social Knowledge

For Q30, academics were provided five (5) options from which they were asked to select the two (2) which they perceived to be the most important barriers to innovating within the role of engineering educator responses (Figure 12).

The most significant barriers were identified as ‘Time taken away from research’ (34.5%) followed by ‘Lack of available funding’ (26%). The third largest contribution from the ‘Other’ response category (16.6%) appears to be respondents clarifying this option related to the ‘Time’ required to be innovative:

“Time overall... not specifically taking it from research, just fitting it all in ...”

Most respondents identified workload concerns, time to reflect, and the lack of clear processes to guide successful innovation in teaching. No less important were a significant number of responses related to the perceived lack of institutional support and incentives other than promotion.

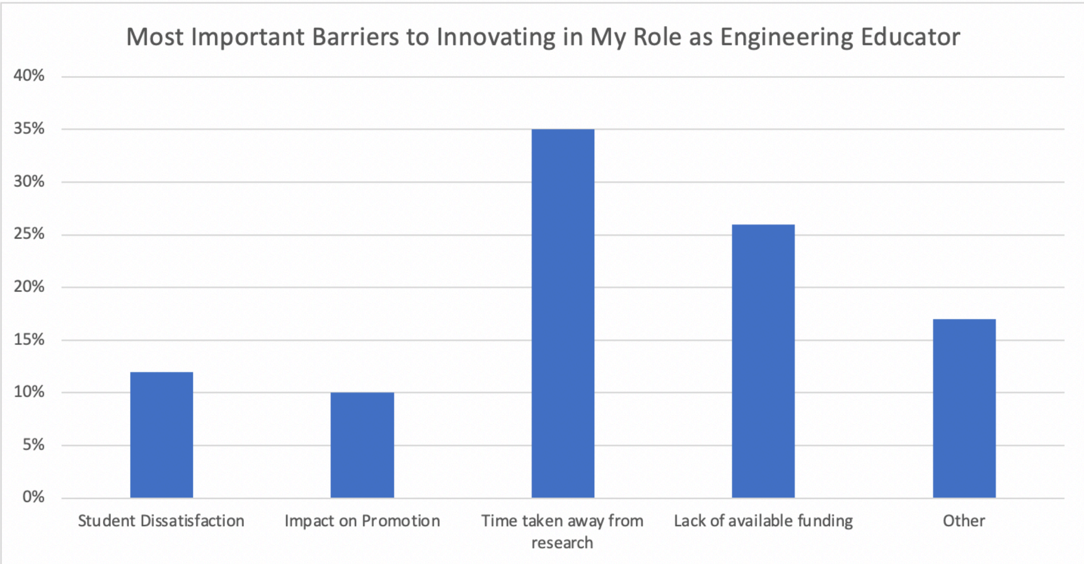

Figure 12: Most Important Barrier to innovate as an engineering educator

3.2.6 Perceived barriers between T&L Leaders vs T&L Staff

Comparison of respondents in a ‘Leadership’ role to those within ‘T&L Staff’ roles indicate two (2) areas where there was a distinct difference in perceived importance. Those in ‘Leadership’ roles ranked ‘Lack of available funding’ and ‘Time taken away from research’ as equally the most important (23%). Those in ‘T&L Staff’ roles nominated ‘Time taken away from research’ (35%) as more than twice as important as their second ranked choice of ‘Student Dissatisfaction’ (17%). Those in ‘Leadership’ roles were nearly three times as likely to further elaborate through the option ‘Other’ (25% vs 9%). Only a small number or respondents (10%) did not to respond (DNR).

Table 3 illustrates the percentage breakdown of perceived barriers by role within the ‘Leadership’ and ‘T&L Staff’ cohorts respectively.

Table 3: Barriers to Innovation (Leadership vs T&L Staff)

LEADERSHIP (N = 40)

	Other	t-Research	Funding	Stud Sat	DNR	Promotion
Associate Dean	5	3	3	1	1	2
HoD	2	3	2	0	1	1
HoS	3	3	4	4	2	0
Totals	**10**	**9**	**9**	**5**	**4**	**3**
Percent	25%	23%	23%	**13%**	**10%**	**8%**

T&L STAFF (N = 317)

	t-Research	Stud Sat	Funding	DNR	Promotion	Other
Professor	26	16	9	11	2	11
Associate Prof	26	6	14	7	7	4
Senior Lecturer	24	20	13	9	16	11
Lecturer	35	13	12	14	10	1
Totals	**111**	**55**	**48**	**41**	**35**	**27**
Percent	35%	17%	**15%**	**13%**	**11%**	9%

Within the 'T&L Staff', academics who hold 'Lecturer' roles were significantly more likely to identify 'Time taken away from research' and 'Student Satisfaction than those in other roles.

Figures 13 and 14 further illustrates the differing perceptions between 'T&L Leadership' and 'T&L Staff'.

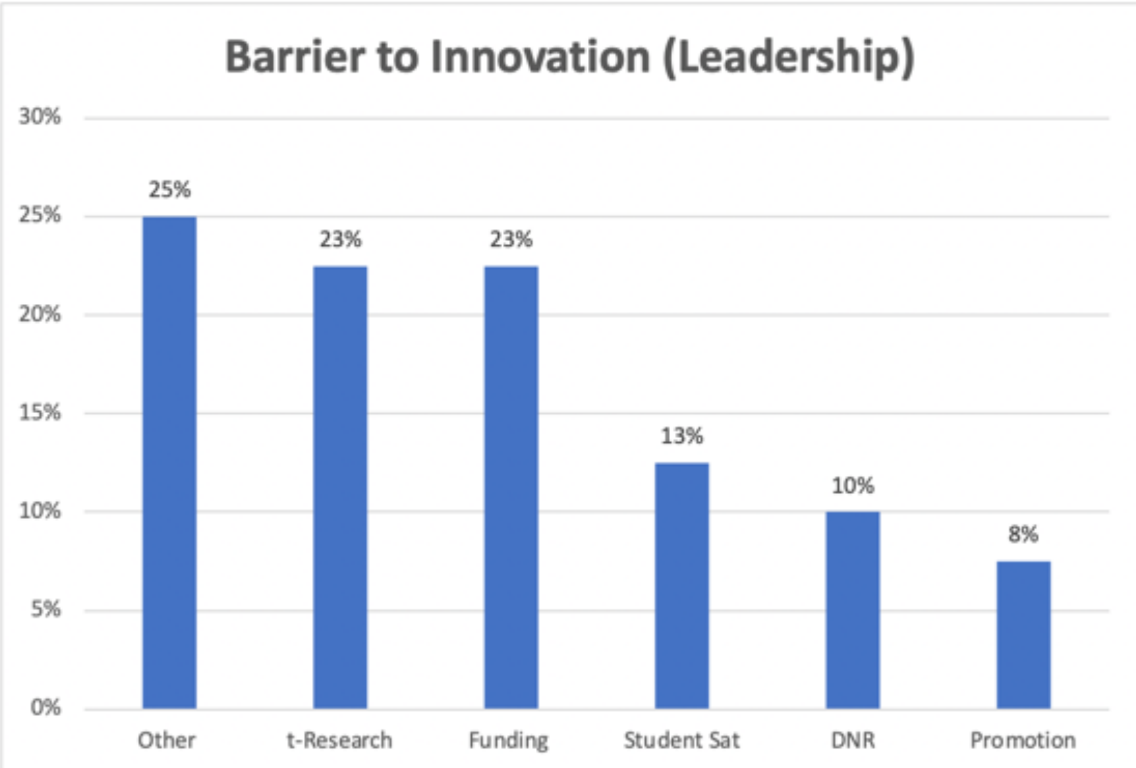

Figure 13: Barriers to Innovation, as reported by 'Leaders'

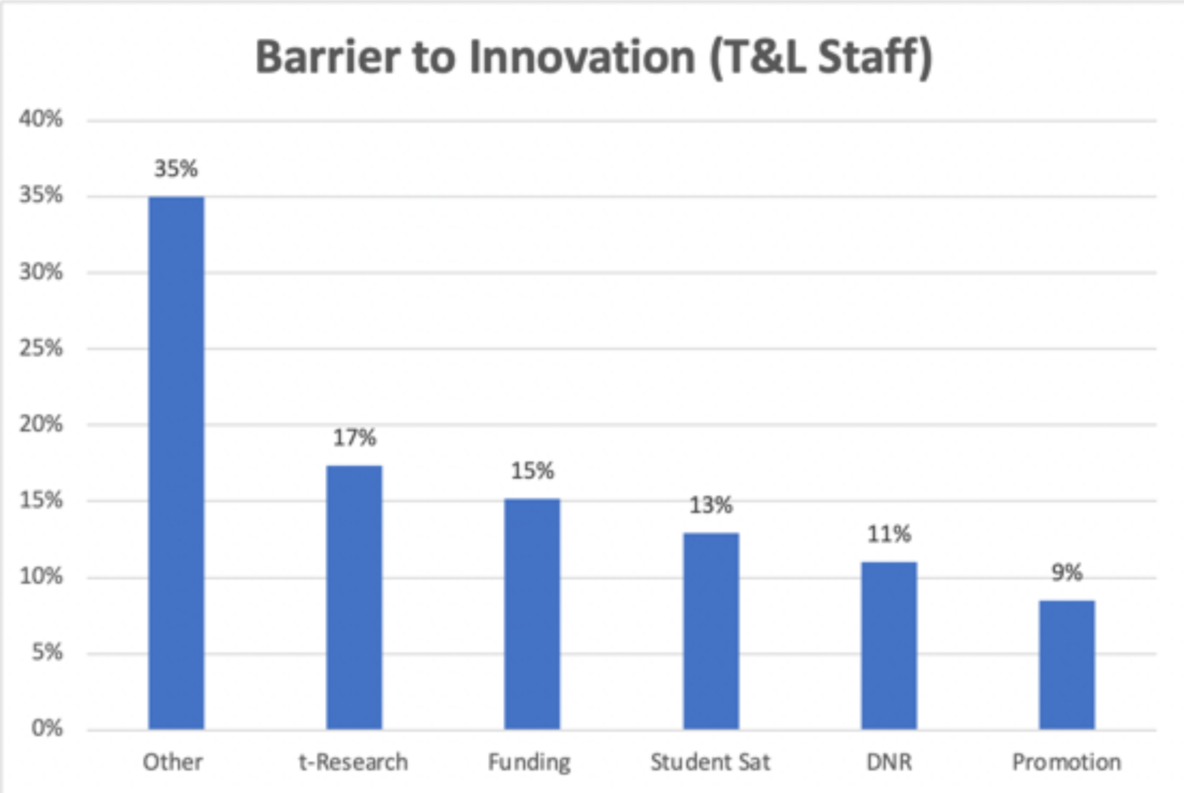

Figure 14: Barriers to Innovation by 'T&L Staff' (non-Leaders)

3.2.7 Perceptual difference in support between T&L Leaders and T&L Staff

Figure 15 shows the mean response value (Completely Agree = 1 to Completely Disagree = 9) of academics in 'T&L Leadership' roles towards perceptions of 'Support' from either their local 'Leadership' or from their 'Institution'. This distinction was made with respect to behavioural studies (Ajzen, 1986) that suggest that a person's behaviour is more likely to be influenced by the attitudes, beliefs and behaviours of those in more local positions of authority (Dean, Heads of disciplines) than the more abstract concept of 'Institution'.

The results show that there is a consistent one (1) full point higher agreement towards perceived support by 'T&L Leadership' than there is for academics who occupy 'T&L Staff' roles. While this pattern may reflect a naturally occurring artefact of a competitive academic culture/organisation, it may also reflect a degree of uncertainty or general dissatisfaction with decisions made by leaders of Faculties, Schools and Departments. Further investigation is recommended.

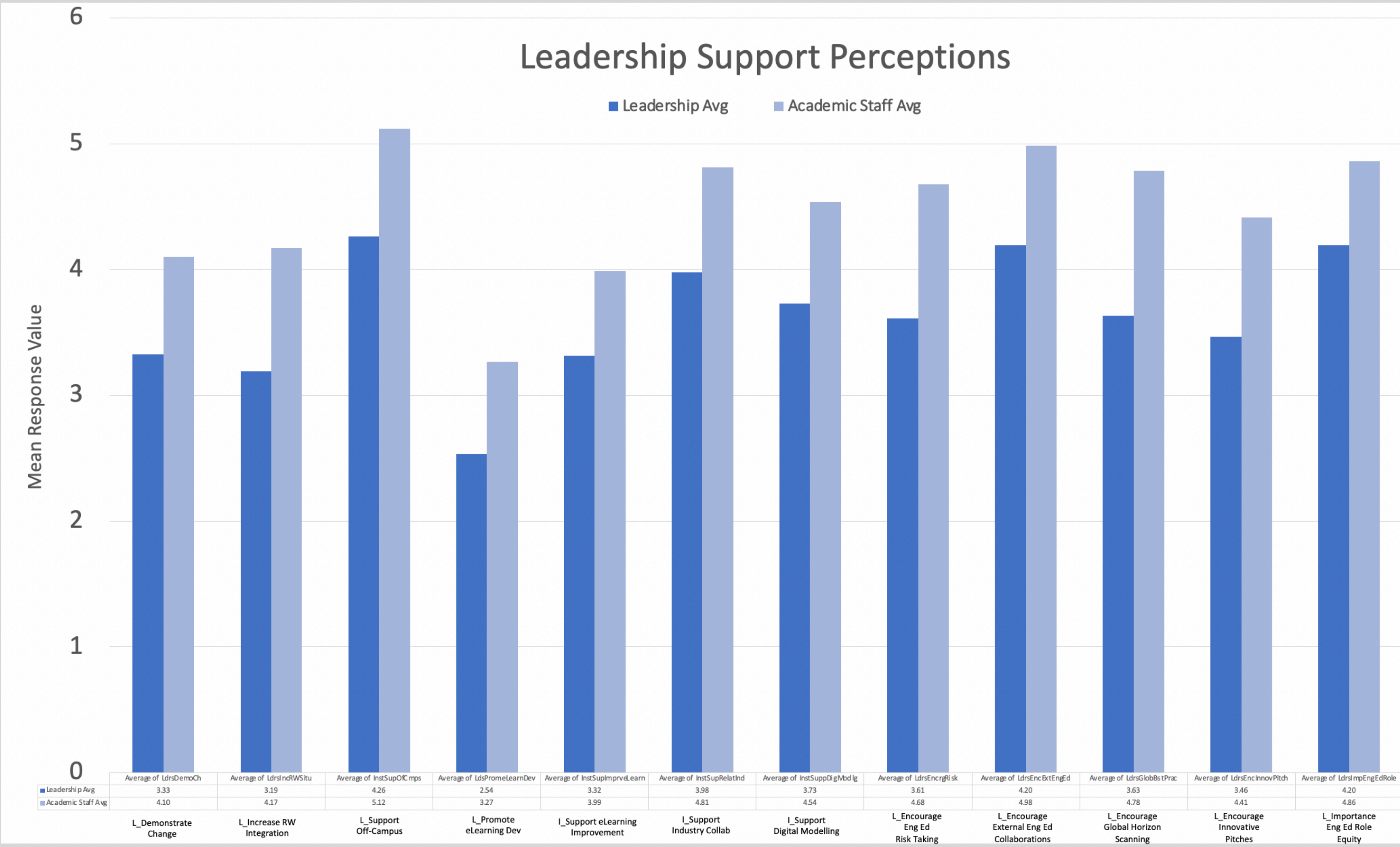

Figure 15: Perceived Leadership and Institutional Support

3.2.8 Transformational Change

The survey sought to test the proposition that engineering academics were comfortable with the terminology of “Transformational Change” (Crosthwaite 2019), by examining their attitudes towards the pace of change with the following statement:

Q20.2 *Incremental changes to the way I teach will be more effective than rapid changes*

Academics strongly and overwhelmingly agreed with this statement (Figure 16) suggesting a solid (and unsurprising) disposition towards an incremental strategy for changing the way they approach their teaching. The dramatic changes to curriculum effected by COVID-19 suggests however, that rapid change is possible when a clear agenda for change has been established by university leadership.

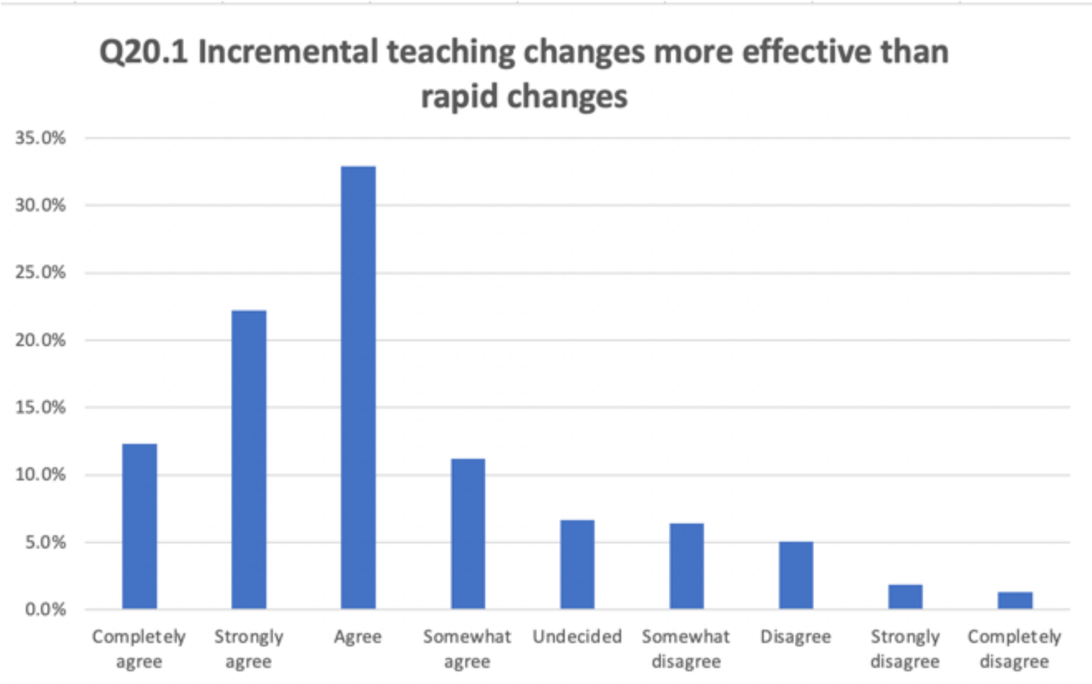

Figure 16: Incremental vs Rapid Change in Teaching

3.2.9 Risk and Innovation

While engineering academics appear to express stronger support for incremental change than rapid change, any significant or rapid change to the curriculum or in teaching methodology brings with it some degree (however unlikely) of potential failure. Aversion to failure, whilst an excellent quality to have with regard to engineering an aircraft’s performance, may not be the optimal mindset when it comes to engineering a future curriculum. While the survey utilised a number of variables related to perceptions of risk and innovation, Figure 17 compares the following two statements (lower numbers indicate higher levels of agreement):

Q28.5 Learning how to take risks in teaching and learning practice is an important ability in my professional development as an engineering educator
Q28.8My leadership encourages me to take calculated risks in developing myself as an engineering educator

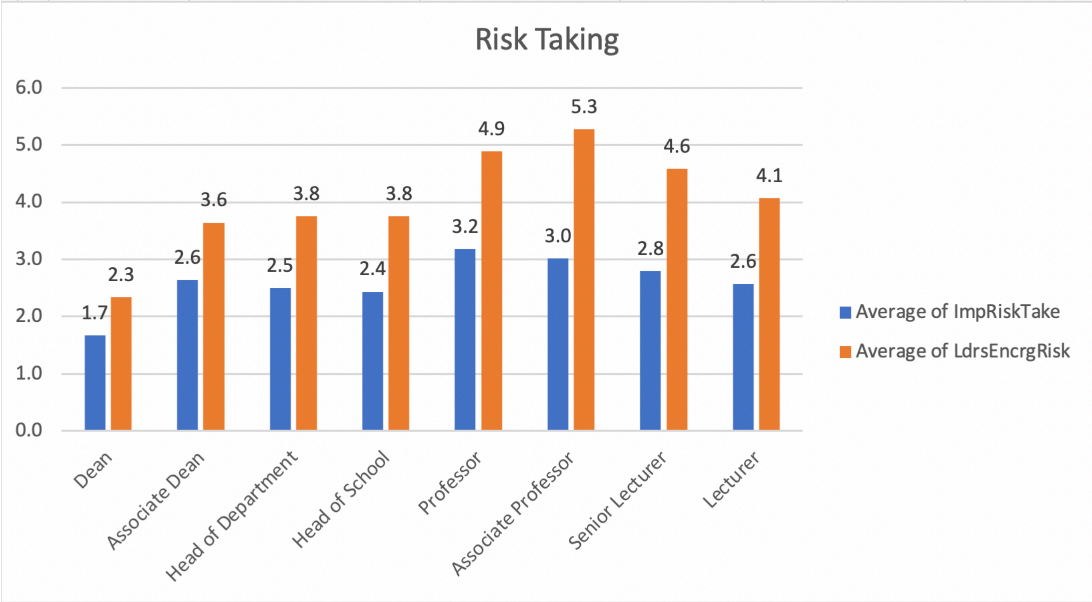

Figure 17: Risk taking

What appears to be clear is the gap between different academic roles in their belief in the 'Importance of Learning how to take risks' in developing their roles as engineering educators and their perceptions of the degree to which their 'Leadership encourages' taking such risks. The gaps between the two bars are smaller for the leaders (leftmost 4 categories) and larger for the non-leaders (right 4 categories).

While further investigation is needed, the results suggest that the important leadership capability of decisiveness examined by (Scott, et al, 2008) does not appear to translate from the strategic to the tactical or operational roles involved with T&L change. This (at first glance at least) suggests additional attention be given to solutions that can address this discrepancy in order to create a sufficient critical mass towards risk taking that will be required to achieve the vision of future curriculum heralded by the 2035 Report (Crosthwaite, 2019).

3.2.10 Persuasiveness and Reception to Innovative Pitches

Figure 17 suggests that while taking risks is perceived as important to T&L leadership, it is not viewed by T&L staff as something that is being encouraged by leadership. This perception appears to be somewhat reinforced by the results of examining how academics value the importance of persuasiveness in pitching innovative ideas to leadership as shown in Figure 18. The statements examined were:

Q28.7 Learning to be persuasive is an important skill to develop for me as an engineering educator

Q29.1 My leadership actively encourages me to pitch innovative ideas to them to enhance my development as an engineering educator

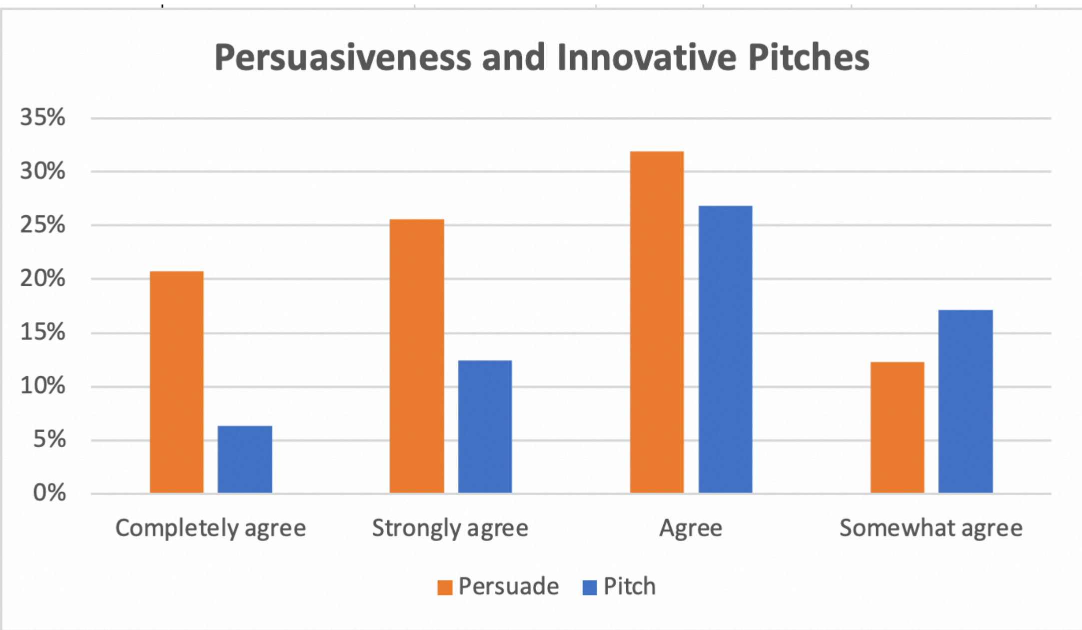

Figure 18: Persuasiveness and Innovative Pitches to Leadership

As shown in Figure 18, over 90% of all respondents agreed with the importance of the ability to develop persuasiveness as a skill. Again, there appears to be perception that utilising this skill towards pitching innovative ideas to leadership is not well received, with only 18% either completely or strongly agreeing that their leadership actively encourages such behaviour.

3.3 Big picture perspectives

The previous discussion has generally concentrated on specific aspects of the survey statements trying to understand the details of the responses. This section looks at the total response picture, seeking to understand the wider-scale aspects of people and attitudes that make up the whole data set.

To do this several approaches were taken, including an Exploratory Factor Analysis (EFA), a Cluster Analysis, and a regression of the factors onto 'Intention'. The following describes what was done and the outcomes.

The work was conducted in collaboration with Associate Professor Jason Lodge, School of Psychology, The University of Queensland.

3.3.1 Exploratory factor analysis (EFA)

An EFA was used to help explain the correlations amongst the 74 statements (variables) that made up the survey instrument. The technique seeks to capture the variance by means of separate 'factors' which are combinations of the original variables. Each factor requires interpretation in terms of the particular variables that dominate or ‘load’ onto the individual factors. This requires insight from the survey designer(s) as to how the group of variables within a factor might be interpreted.

For the survey, 8 factors from a total of 74 were chosen based on their overall significance in capturing the variance in the data set. These factors represented about 60% of the total variance. After using a data rotation technique (‘Promax’) and a 0.4 cut-off value for the ‘loadings’ on each factor, this permitted an interpretation of the set of original variables loaded onto each of the 8 factors. There was a total of 367 respondents in the data set that was used.

The resultant 8 factors can be interpreted in the following way:

- ***Factor 1*: Leadership and support**: was dominated by statements around leadership, encouragement and provision of support.
- ***Factor 2*: Real-world and industry collaboration**: was dominated by the importance seen in these areas, confidence that it would drive the development of student capabilities, and importance to invest time in this activity.
- ***Factor 3*: Confidence in abilities**: was dominated by personal beliefs in respondents’ abilities to achieve outcomes across nearly all areas of activity.
- ***Factor 4*: Social and human aspects**: captured social and human aspects and investment of time into understanding these areas,
- ***Factor 5*: Peer influence**: was dominated by social and human aspects and investment of time into understanding these areas
- ***Factor 6*: Importance of e-Learning**: was a major factor dominated by e-Learning areas of importance, adoption, professional development of graduates and respondents’ commitment to the task.
- ***Factor 7*: Trends**: captured areas related to future activities such as personal development, horizon scanning, development as an educator.
- ***Factor 8*: Modelling**: was dominated by time commitment, confidence and peer activity in use of digital technologies for modelling systems.

The factor analysis was helpful in seeing the broader attitudes of respondents and the future challenges of preparing academics for future educational innovations. It was noted that Factor 6 “e-Learning” explained around 32% of the variance in the data set. Factor 2 “Real-world and industry collaboration”, in statement areas Q21 and Q26 of the survey, accounted for 20.5%.

3.3.2 Cluster analysis

Using the individual statements under each factor, a new, re-organized data set was generated and used to do a cluster analysis. This was to investigate and classify the nature of subgroups of respondents across those factors. To this set was added the “Intention to invest more time and effort to change my teaching in the next year”.

The cluster analysis was based on k-means clustering which requires the user to nominate the number of clusters being sought from the data. In this case 8 clusters were chosen. Clusters represent respondents who had similar responses compared to other subgroups. It is an approximate classification technique.

The result of the cluster analysis is shown in the following plot. It shows the original 8 factors from the EFA plus the “Intention to change” statement:

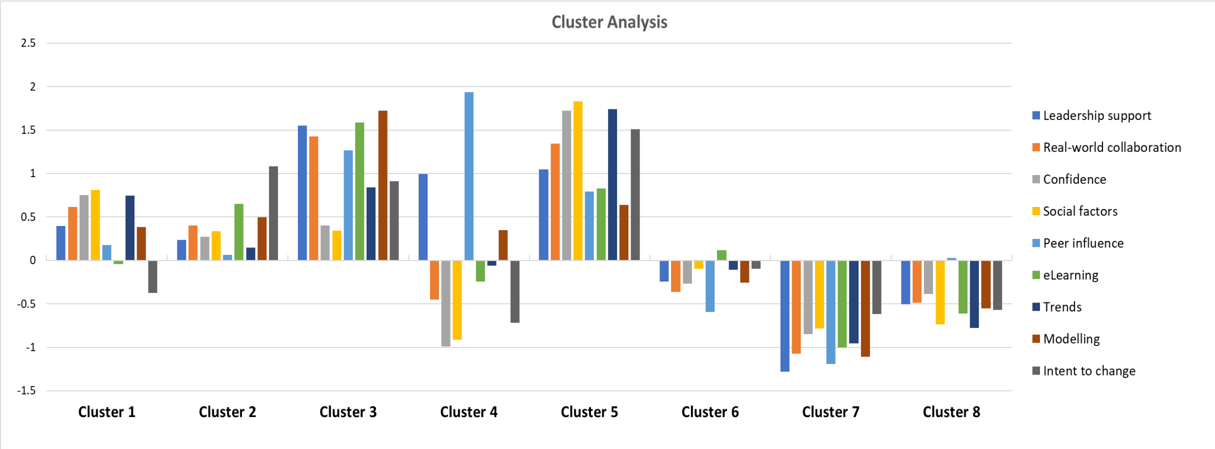

Figure 19: Cluster analysis across major exploratory factors

The clusters are grouped along the abscissa, with the various factors shown in the legend. The plot shows the relative positive or negative perception for each factor within a cluster.

An interpretation of the way the various clusters are distributed could be as respondents who are:

- ***Cluster 1***: Average across most factors except for the ‘importance of social-human aspects’ in education [16% of respondents in this cluster]
- ***Cluster 2***: Respondents who are positive around e-Learning and intention to change. [15% of respondents in this cluster]
- ***Cluster 3***: People who are relatively positive across most factors except for confidence and social factors. [7% of respondents in this cluster]
- ***Cluster 4***: Pessimistic respondents with strong peer connections but not wanting change. [5% of respondents in this cluster]
- ***Cluster 5***: Those who appear to be very confident and positive towards change [6% of respondents in this cluster]
- ***Cluster 6***: Slightly negative respondents who don’t have much faith in their peers [19% of respondents in this cluster]
- ***Cluster 7***: People who are negative about everything with no intention of doing anything [13% of respondents in this cluster]
- ***Cluster 8***: Similar people to Cluster 7 but have stronger belief in their peers. [19% of respondents in this cluster]

The cluster analysis highlights group characteristics within the data set. The clusters also highlight where strategies might be required to aid people in their future activities and at the same time help address shortcomings or barriers that might exist in a particular situation. Of particular interest are clusters such as 4, 7 and 8 where there is a strong, negative attitude towards intention to change. This represents around 37% of respondents. Another group, represented by clusters 2, 3 and 5 shows that 28% of respondents are strongly positive towards change, with the rest being neutral.

3.3.3 Regression of factors onto ‘Intention to change my teaching’

The final activity was to consider the extent to which each of the 8 factors from the EFA regress onto ‘Intention to invest more time and effort to change my teaching in the next year’.

A multiple linear regression was carried out on the data set, with each factor representing one of the 8 ‘independent’ variables with ‘Intention to change teaching’ as the dependent or outcome variable.

The results gave the following insights:

- Two factors dominated the prediction of ‘Intention to change’:
  - *Factor 6*: Importance of e-Learning, contributed 31.6% towards ‘Intention to change my teaching’
  - *Factor 2*: Real-world and industry collaboration, contributed 20.5% towards ‘Intention to change my teaching’
- A third factor was also considered statistically significant:
  - *Factor 3*: Confidence in abilities, contributed 10% towards the ‘Intention to change my teaching’.
- All other factors were not regarded as significant at a confidence level of < 90%.

This outcome suggests that the intention to invest time and effort to change teaching practice in the next year is driven primarily by the role that e-Learning has had and will have into the future. The other dominant factor is the belief that real-world situations and industry collaboration provide the means to better prepare future graduates for their professional roles.

These attitudes are supported by the belief that academics have the abilities to deliver those learning outcomes, with some noticeable caveats related to dealing effectively with social and human factors in engineering and supporting future graduate education in community settings.

4 Discussion and Recommendations

4.1 T&L Strategies

4.1.1 Importance of change strategies (direction of change)

This report has presented a summary of the major findings and initial interpretations extracted from the survey instrument data, based on demographic, descriptive statistics, and exploratory factor analyses. These analyses suggest an academic workforce that most values the importance and effectiveness of three out of the five teaching strategies (Appendix E) examined in this survey:

- 'e-Learning' (90% agreement),
- 'Using Real World Integration in my teaching' (87% agreement), and
- 'Collaboration with industry' (82% agreement).

4.1.2 Confidence in abilities to engage in these strategies

While academic staff are highly confident (90%) in their abilities to facilitate these three strategies, their intentions to adopt or make further efforts towards them in the next year or two (with the exception of e-Learning) are significantly lower (70%) than their stated importance. While confidence, in and of itself, is not a suitable proxy for capability, the combination of both importance and confidence suggests a strong potential for adoption provided that adequate steps are taken by ACED.

4.1.3 Professional development (context and time spent) to enable change strategies

Overall, academic staff agree with the importance of both maintaining an awareness, as well as investigating global best practice to support their continuing professional development as an engineering educator. However, their intentions to spend time on these and other activities associated with developing their abilities as engineering educators are even lower (< 60%) than their intentions to adopt the curriculum change strategies surveyed in this report. These results tend to suggest a significant cohort of academics adopting an informal or intuitive approach to T&L scholarship identified in (Jamieson 2012) and (Trigwell 2000).

Asked to identify barriers to innovating in their role as engineering educators, the majority of academics identified 'Time taken away from research' (35%) and 'Lack of available funding' (26%) as the two most significant, followed by 'Student Satisfaction' (13%) and 'Impact on Promotion' (11%).

The historical prioritisation of academic research outcomes over that of teaching, combined with the restructuring currently underway across institutions to adapt to international student fee income losses, suggests an academic staff under significant pressure to rationalise their workloads in what can only be described as a significantly challenging environment. Any future initiatives towards reshaping the workforce should place a high value on minimising further pressure by aligning change in the direction most highly aligned to what academics believe are important and effective as well as in the direction with the most significant momentum.

These results suggest workforce change strategies that focus on time efficiencies as well as curriculum initiatives that provide a more holistic context for academics to learn from.

Recommendation 1: *Develop* ***pilot projects*** *for innovative curriculum initiatives that require industry practitioners to collaborate with engineering academics on creating and delivering authentic real-world learning experiences.*

4.1.4 Building on e-Learning infrastructure investments

While it would be premature to draw absolute conclusions from the beliefs and perceived barriers expressed in the survey responses, the data paints a strong picture of academic staff who, not surprisingly, appear to be driven by the immediate concerns of developing e-Learning infrastructure in response to the COVID-19 pandemic over the course of 2020.

This suggests adopting a digital strategy as the backbone for achieving change that also aligns well to a number of other recommendations in this report. Emphasising an online/virtual approach can leverage the momentum and conceptual shifts identified in this survey regarding the effectiveness of e-Learning that have occurred over the 2020 period of transition. The changing nature of industry work from traditional face-to-face meetings to more flexible work-from-home virtual meetings suggests an opportunity to address the time barriers inherent in expanding academic and industry collaboration through on-site activities alone. Adopting an online approach would also provide for an increased level of communication and transfer of contextual knowledge between engineering academia, education experts and industry that will be required to engage more fully and at a higher level of educational best practice (Reidsema et al. 2013). A digital strategy also lends itself to many long term cost efficiencies in:

- identifying and cultivating real world Australian industry and community problems that can be utilised for learning in multiple spaces (virtual, on-campus, in-industry and in-community)
- building relationships between academics, students and industry practitioners.

Recommendation 2: *These pilot projects should build on the use* ***of online/digital*** *technologies to connect and develop relationships between industry practitioners and T&L academics responsible for designing the new curriculum.*

4.2 Culture of Change

Because academic perceptions of cultural norms (attitudes, beliefs and behaviours of peers, leadership, and institution) play a strong role in influencing behaviours, the survey investigated a range of variables to highlight these perceived norms.

4.2.1 Pace of change/ Innovation and Risk

Academics have undoubtedly done a remarkable job in response to the COVID-19 pandemic by transforming their T&L (and academic working!) environments from a mostly face-to-face (physical) environment to one which is almost totally online (virtual). Nevertheless, they remain by and large averse to rapid or transformative change, preferring an incremental and risk managed approach. This successful adaptation to what was an externally imposed threat, supports an argument for continuing to communicate a clear sense of urgency and for decisive executive leadership to maintain the T&L change momentum developed in 2020 by defining future engineering learning in tighter and broader collaboration with industry (Kotter 2007, Graham 2012).

A top-down approach alone will not be sufficient and may exacerbate underlying tensions identified in the cluster analysis discussed earlier (3.3.2). The survey results also suggest that academic staff perceive their leadership as not being receptive to innovative pitches, which in turn could inhibit the long-term growth of bottom-up creativity, which is necessary to respond to future graduate needs. This finding, combined with the observation that when it comes to changing their teaching, academic staff are more likely to emulate their peers than their leaders, suggests a focus on identifying and developing T&L 'Change Agents'.

In regard to expanding and developing long-term collaborative relationships with industry, not all academic staff are comfortable in dealing with industry personnel and/or environments. Many find industry to be 'foreign territory'. Where there exist academic staff with substantial industry experience, mentoring arrangements should be in place to acculturate and support those staff who might be hesitant in their approaches to industry. Most organisations have staff who are adept at networking and able to facilitate knowledge transfer between domains acting as 'boundary agents' between two distinct worlds (Calder, 2007).

Scalable solutions to curriculum require "change agents" to lead and/or manage the types of curriculum initiatives and curriculum environments to enable authentic training and academic development (Reidsema et al. 2017). Building relationships with industry helps transfer knowledge and skills between domains and this needs to be supported by an extrinsic reward structure such as academic promotion. This will in turn require documentation processes which are both time efficient and targeted as well as able to evidence progressive professional development at the same level required for maintaining a Chartered Professional Engineer status through Engineers Australia (EA).

Recommendation 3: *Identify and support both 'change' and 'boundary' agents who are willing and able to be involved in the proposed pilot projects.*

4.2.2 Leadership Expectations

In terms of strategies, the data suggests that academics believe that their T&L Leadership have low expectations for them to pursue integration into the curriculum of either Real-World issues (57%) or Human and Social issues (55%). This is despite the quite high levels of importance that academic staff place on these two strategies (87% and 74% respectively).

In terms of equipping themselves with a broader understanding of engineering's relationship to society, it is interesting that academics tend to believe in the importance of non-disciplinary bodies of knowledge (87%), as well as the importance of spending time developing their understanding of non-technical knowledge (82%). These findings have implications for achieving the 2035 report's 'T-shaped' engineering graduate capabilities and raise questions on the types of knowledge academics believe are important, as well as the amount of effort that is currently spent on this activity or that could be expected in the future.

This gap between what types of curriculum strategies engineering academics believe are important and what they believe are feasible, rests largely on what evidence they seek out through scholarship, what they are provided by their institutions, and what expectations are set by their T&L leadership. In either case, the issue is predominantly one of communication be it internally derived through change agents, or externally via collaboration with other institutions or professional bodies such as the Australasian Association of Engineering Educators (AaeE) and EA.

In terms of motivation however, the survey suggests that T&L academic staff perceive that their leadership have quite low expectations for them to collaborate with other institutions on engineering education (42%) and for them to expend effort in seeking out evidence of global best practice to support their development as engineering educators (49%). Despite nearly two decades of concerted effort by government and institutions to raise the status of T&L academic roles (Probert. 2013), academic staff express significant doubts that their leadership believe in the equity of T&L development with that of a discipline-based research role (49%).

4.2.3 Institutional Rewards

Overall, there is a low perception by academic staff that their institutions reward them in important areas of development aligned to the future graduate capabilities envisioned in the 2035 Engineering Futures report:

- Changing their teaching (44%),
- Increasing the effectiveness of e-Learning (47%),
- Collaborating with industry for the purpose of improved learning (47%), and
- using digital technologies to model engineering problems (44%).

This very low perception of institutional rewards, and perceived support for future T&L changes combined with evidence of a significant cluster of respondents (40%) expressing negative views towards change should be of serious concern. Although progress has been made over the past decade in developing promotional pathways based on T&L (Probert 2013), the survey results reveal a very low number of senior academic staff seeking future promotion with a strong emphasis as an engineering educator (avg. 40%):

- Lecturer 66%
- Senior Lecturer 52%
- Associate Professor 28% (52% disagree)
- Professor 15% (57% disagree)

Factoring in the perception that the major reported barrier to further professional development is 'time taken away from research' suggests that a strategy that seeks to improve the balance between extrinsic and intrinsic rewards with a focus on minimising additional time commitments should underpin any meaningful 2035 Engineering Futures workforce engagement and development solution.

Promotion is one way to address an enhanced program of reward for effort directed towards activities associated with the strategic initiatives recommended by this report **(R1-R4).** The additional effort required to achieve increased collaboration with industry to develop real-world curriculum, supported by online/digital infrastructure was forecast nearly a decade ago as a major driver in the evolving differentiation of academic workforce roles (Probert 2013).

While there has undoubtedly been some shift towards recognising and rewarding academics who seek promotion with an emphasis on teaching (Graham 2019), increasing the pace of promotion is constrained by limitations on what would constitute acceptable evidence of achievement. The more easily recognised and agreed upon evidence is largely, but not exclusively limited to student satisfaction surveys of academic teaching and subject/course performance, as well as scholarly publications in the field of engineering education.

Existing methods for producing evidence of professional achievements in T&L in support of academic promotion are still somewhat ambiguous, overly time consuming and documentation heavy (HEA FAQs 2019). A more extensive and targeted system for collecting evidence in support of promotion aligned with the 2035 workforce requirements should be adopted by ACED. Such a system should be able to meet flexibility, transparency, and ease of adoption criteria.

Recommendation 4: *Conduct a national review of initiatives that encourage* ***development, reward and promotion*** *for T&L staff.*

4.2.4 Continuing Professional Development

Engineers Australia's (EA) model for Continuing Professional Development (CPD) to meet and maintain the requirements of Chartered Professional Engineer (CPEng) status serves as a useful template for this recommendation. Such a system would enable both academic and industry practitioners to demonstrate a standardised level of development and scholarly practice oriented to building deeper connections and engagement with industry, the community and other parts of society (Vardi 2010). Additional criteria for such a CPD system should:

- Provide low effort evidence for academic promotion
- Provide strategic information on progress to institutional leadership
- Utilise digital affordances to:
    - Facilitate sustainable relationships with industry, and
    - Provide digital training and credentialling for both academics and industry practitioners

This final recommendation (R5) would form a coherent part of an application for government funding for pilot projects consisting of R1 (contexts); R2 (digital relationship with industry) and R4 (enabling academic educational development).

Recommendation 5: *Develop a roadmap for implementing a national program for Continuing Professional Development (CPD)*

4.3 Next steps

The next 2-5 years will be marked by Australian Higher Education Institution's focus on resolving the issues that have been imposed on it by the 2020-2021 COVID-19 pandemic. Engineering will need a T&L academic workforce that is more highly educated, more willing to take risks with their teaching and who are more easily able to engage with industry in the development of new curriculum that can leverage the transformational changes that are occurring in both virtual and physical learning spaces over the next few years. This workforce will require a more substantial and strategic effort by ACED towards supporting and rewarding the continued effort.

In regard to achieving T&L changes that can meet the shift in graduate capabilities signified in the 2035 Engineering Futures report, Government funding will be important for innovating more authentic curriculum pilot projects with the aim of:

- Increased utilisation of online/digital platforms

- Re-conceptualising physical T&L spaces to more closely align with the shift in more flexible work from home virtual environments.

- Academic workload and T&L resource cost efficiencies

- Government support for 'employability/job-ready' graduates

- A more structured and transparent system that can account for educational professional development activities aligned to the major objectives of the 2035 report. This includes professional practice, real-world issues and industry collaboration.

Over the last 30 years, ACED has sponsored the development of the Australasian Association for Engineering Education (AAEE), a national community of engineering education scholars, of international reputation. Now is the time to use the knowledge and skills of the AAEE community to respond to the above recommendations.

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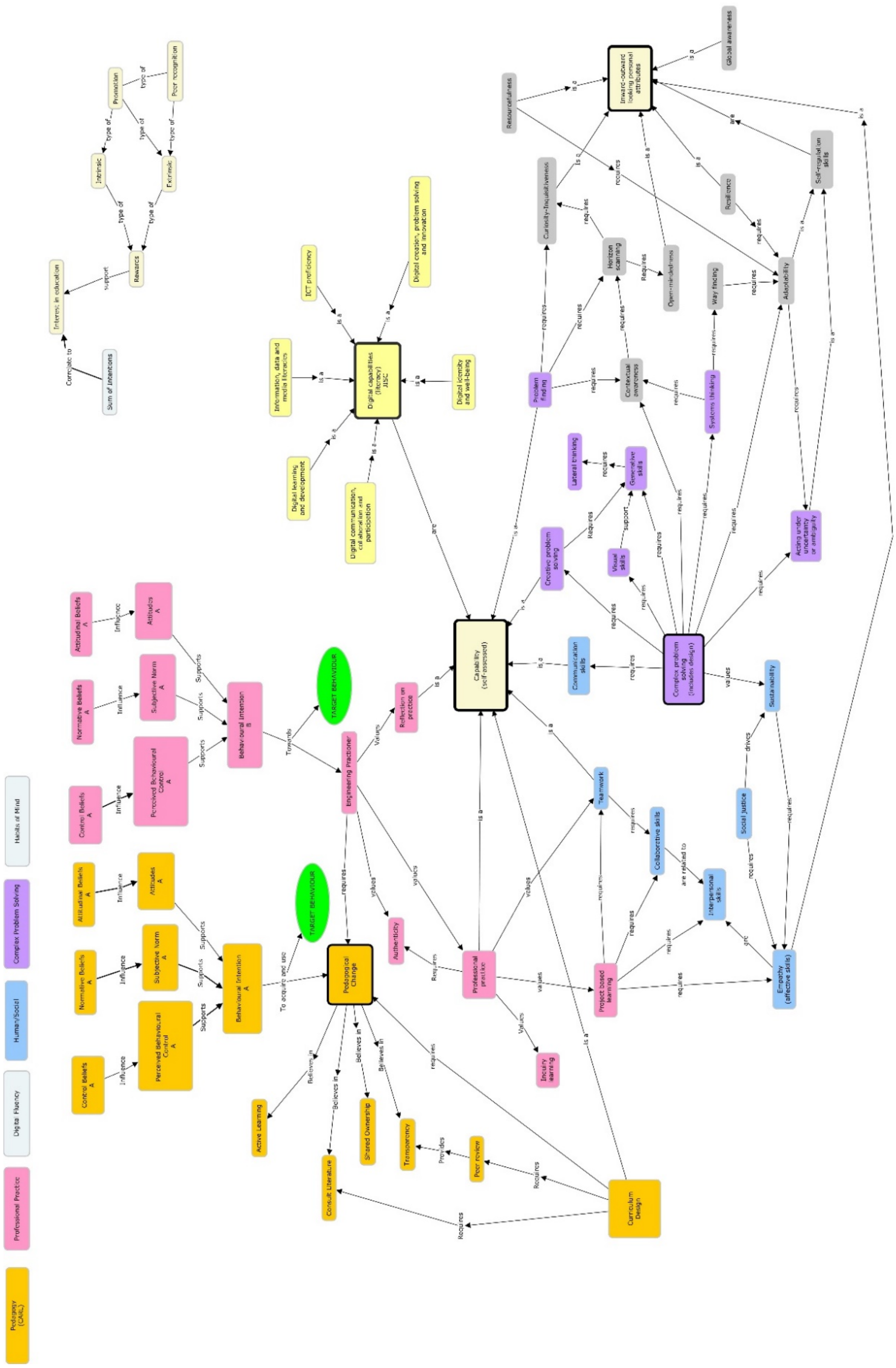
6 Appendices

6.1 Appendix A: Concept map



6.2 Appendix B: Response data by Faculty

TABLE A1

Institution - GO8	Attempts	Finished	Incomplete	Average % Finished	Total % Contribution	Type
Monash University (MONASH)	52	38	14	0.7308	10.2%	LRU
University of Queensland (UQ)	46	35	11	0.7609	9.4%	LRU
University of Adelaide (ADELAIDE)	45	27	18	0.6000	7.3%	LRU
University of NSW Sydney (UNSW)	21	17	4	0.8095	4.6%	LRU
University of Melbourne (MELBOURNE)	16	10	6	0.6250	2.7%	LRU
University of Western Australia (UWA)	10	9	1	0.9000	2.4%	LRU
Australian National University (ANU)	6	4	2	0.6667	1.1%	LRU
University of Sydney (SYDNEY)	4	3	1	0.7500	0.8%	LRU
Total Count (All)	**200**	**143**	**57**	**73.0%**	**38.4%**	
				Average		
Institution - METRO	**Attempts**	**Finished**	**Incomplete**	**% Finished**	**% Contribution**	**Type**
University of Technology Sydney (UTS)	31	21	10	0.6774	5.4%	METRO
Macquarie University (MACQUARIE)	22	17	5	0.7727	4.4%	METRO
RMIT University (RMIT)	23	15	8	0.6522	3.9%	METRO
University of Tasmania (UTAS)	15	14	1	0.9333	3.6%	METRO
Swinburne Univers…ology (SWINBURNE)	17	13	4	0.7647	3.4%	METRO
Queensland University of Technology (QUT)	14	8	6	0.5714	2.1%	METRO
University of South Australia (UNISA)	7	6	1	0.8571	1.6%	METRO
La Trobe University (LATROBE)	6	5	1	0.8333	1.3%	METRO
University of Canberra (CANBERRA)	7	5	2	0.7143	1.3%	METRO
Western Sydney University (UWS)	10	5	5	0.5000	1.3%	METRO
Curtin University (CURTIN)	8	5	3	0.6250	1.3%	METRO
Deakin University (DEAKIN)	6	4	2	0.6667	1.0%	METRO
University of NSW Canberra (ADFA)	2	2	0	1.0000	0.5%	METRO
Edith Cowan University (ECU)	1	1	0	1.0000	0.3%	METRO
Total Count (All)	**169**	**121**	**48**	**75.5%**	**31.3%**	
Institution - REGIONAL	**Attempts**	**Finished**	**Incomplete**	**% Finished**	**% Contribution**	**Type**
University of Wollongong (UOW)	32	24	8	0.7500	6.5%	REGIONAL
University of Southern Queensland (USQ)	17	16	1	0.9412	4.3%	REGIONAL
Griffith University (GRIFFITH)	18	13	5	0.7222	3.5%	REGIONAL
University of Newcastle (NEWCASTLE)	17	11	6	0.6471	3.0%	REGIONAL
Federation University Australia (FedUni)	6	6	0	1.0000	1.6%	REGIONAL
University of the Sunshine Coast (USC)	7	6	1	0.8571	1.6%	REGIONAL
Victoria University (VU)	6	6	0	100.0%	2%	REGIONAL
Central Queensland University (CQU)	5	5	0	1.0000	1.3%	REGIONAL
Charles Sturt University (CSU)	8	5	3	0.6250	1.3%	REGIONAL
Curtin University (CURTIN)	8	5	3	0.6250	1.3%	REGIONAL
Flinders University (FLINDERS)	4	4	0	1.0000	1.1%	REGIONAL
James Cook University (JCU)	5	4	1	0.8000	1.1%	REGIONAL
Charles Darwin University (CDU)	4	3	1	0.7500	0.8%	REGIONAL
Murdoch University (MURDOCH)	3	3	0	1.0000	0.8%	REGIONAL
Southern Cross University (SCU)	2	2	0	1.0000	0.5%	REGIONAL
	142	**113**	**29**	**84.8%**	**30.4%**	

6.3 Appendix C: Glossary of terms

Ability*: possession of the means or skill to do something (to behave towards a future state)*

Active Learning: *learning that involves "students' efforts to actively construct their knowledge."*

Andragogy*: the method and practice of educating adult learners*

Authentic Learning: *active learning utilising real-world problems (NSSE/AUSSE)*

Autonomy: *the freedom to act*

Behaviour: *the way a person acts (usually observable)*

Digitally Enhanced Learning: *the application of digital technology to deliver student learning*

Efficacy: *the ability to produce/deliver a result (same as "capability")*

Capability*: the extent of someone's ability (influenced by perceived norms and controls/constraints on behaviour)*

Intention: *the likelihood of an action occurring (want or plan of action)*

Pedagogy: *the method (science) and practice (profession) of educating students*

Practice*: the actual application or use of an idea, belief, or method, as opposed to theories relating to the idea*

Problem-Based Learning: *a student-centred approach in which students learn about fundamental concepts of a subject through solving an open-ended problem*

Skill*: a particular ability done well (denotes a level of expertise)*

6.4 Appendix D: Survey Items

Q6: What is your age?
Q7: What is your gender?
Q8: What is your primary engineering discipline?
Q10: Do you have a Full-Time, Part-Time, or Casual Academic Position?
Q11: Is English your most proficient language?
Q12: What is your current academic role?
Q14: What institution do you currently work for?
Q15: What is your percentage contribution to teaching?
Q16: My teaching tends to be:
Q17: My primary area of teaching is best categorised as:

Explanation of the survey
This survey will ask you to respond to statements that address a number of important areas of engineering education that are thought to lead to improvements in the capabilities of future graduates. The survey is structured in terms of:

- What you **believe** or **value** about a specific area of engineering education
- Your perceptions of what **significant others** in your work environment believe about engineering education
- Your perceived **abilities** in a specific area of engineering education and what **barriers** might prevent you from acting
- Your **intention to act** or engage in the specific area of engineering education

Q20: Teaching practice changes towards addressing future graduate capabilities

This section asks you to respond to statements about your beliefs and perceptions regarding the degree to which your teaching may be required to change **in order to meet the future learning needs of graduates**. How well do you believe you handle change and how do you perceive your work environment with regard to the support you receive and any constraints on your ability to achieve change?

1. Substantial changes to the way I teach in the future will be necessary
2. Incremental changes to the way I teach will be more effective than rapid changes
3. My leadership team demonstrates teaching practices that are change oriented
4. When it comes to changing my teaching practices, I will emulate my leadership team
5. Many of my academic peers demonstrate change oriented teaching practices
6. When it comes to changing my teaching practices, I will emulate my academic peers
7. I am confident in my abilities to rapidly change the way I teach, to meet future graduate capabilities
8. I regularly investigate education literature to guide changes in my teaching
9. My institution provides me with adequate support to change the way I teach my courses
10. My institution rewards my efforts in changing the way I teach
11. I intend to invest more time and effort to change my teaching in the next year

Q21: Using real-world situations in my teaching

This section asks you to respond to statements about your beliefs and perceptions regarding the importance and urgency of using current 'real-world' situations to contextualise student learning in more authentic ways than has traditionally been the case. Real-world situations are more ill-structured and open-ended, requiring students to grapple with complexity.

1. It is important that I increase my use of current real-world situations in my teaching
2. I am confident that increasing the use of current real-world situations in my teaching will produce improved graduate capabilities
3. My leadership team thinks that I should increase the use of current real-world situations in my teaching
4. I agree with my leadership team that I should increase the use of current real-world situations in my teaching
5. Many of my academic peers strongly support the use of current real-world situations in teaching
6. Many of my academic peers are already adopting the use of current real-world situations in their teaching
7. I am confident in my abilities to integrate current real-world situations in my teaching
8. I am confident in my abilities to facilitate student learning that takes place off-campus in industry settings
9. I am confident in my abilities to facilitate student learning that takes place off-campus in community settings
10. I am provided the necessary support to develop off-campus student learning experiences
11. Engineers Australia Stage 1 Competencies assist me in understanding what are possible intended student outcomes from off-campus learning experiences
12. I intend to increase my use of current real-world situations in my teaching in the next year

Q22: Using e-Learning to deliver future graduate capabilities

This section asks you to respond to statements about your attitudes, beliefs and perceptions around the use of e-Learning to achieve future graduate capabilities. By e-Learning we mean: 'the delivery of all forms of student learning through online or digital means such as: computer-aided tutorials; video conferencing of lectures and/or tutorials, as well as simulated face-to-face learning experiences.'

1. e-Learning plays an increasingly important role in my teaching
2. I am confident that e-Learning will play an increasingly important role in the professional formation of future graduate engineers
3. My leadership team expects me to adopt more e-Learning within my teaching
4. My leadership team promotes the development of improved methods of e-Learning
5. Many of my academic peers are adopting more e-Learning in their teaching
6. I am confident in my abilities to adopt e-Learning in my teaching
7. I am provided adequate support to achieve my aims in e-Learning
8. My institution rewards me for improving the effectiveness of e-Learning in my teaching
9. I will increase my use of e-Learning in my teaching in the next year

Q23: Integrating human and social dimensions within engineering contexts

Engineering serves society, seeking to address human needs. This section asks you to respond to statements about your attitudes, beliefs and perceptions around integrating social, cultural and historical knowledge within your engineering teaching practice.

1. I am confident that integrating human and social dimensions with technical knowledge in my teaching will improve future graduate capabilities
2. It is important that I invest more time and effort to integrate human and social dimensions with technical knowledge in my teaching
3. My leadership team expects me to integrate human and social dimensions with technical knowledge in my teaching
4. Many of my academic peers are integrating human and social dimensions with technical knowledge in their teaching
5. I am confident in my abilities to integrate human and social dimensions with technical knowledge within my teaching
6. I intend to increase my efforts to integrate human and social dimensions with technical knowledge within my teaching in the next year

Q24: The most important barrier to integrating human and social dimensions with technical knowledge into my teaching would be:

Available time; Student satisfaction; Funding; Lack of expertise; Not relevant to me; None; Other

Q25: A free text option for 'Other'
Q26: Collaborating with industry

This section asks you to respond to statements about your beliefs and perceptions regarding industry collaboration within your teaching to enhance the professional practice capabilities of future graduates. Please note that we are specifically referring to the **Undergraduate** curriculum and not Research and Higher Degrees (RHD).

1. It is important that I invest more time and effort to collaborate with industry to provide practice opportunities for my undergraduate students
2. I am confident that increasing collaboration with industry in my teaching will improve future graduate capabilities
3. My leadership team expects me to invest more time and effort to collaborate with industry to provide practice opportunities for my students
4. Many of my academic peers are actively seeking to collaborate with industry to provide practice opportunities in their teaching
5. I am confident in my abilities to collaborate with industry to provide practice opportunities for my undergraduate students
6. I am provided the necessary support to develop relationships with industry to integrate professional practice in my teaching
7. My institution rewards me for engaging with industry to integrate professional practice in my teaching
8. I intend to invest more time and effort to collaborate with industry to provide practice opportunities for my undergraduate students in the next year

Q27: Digital technologies to model engineering problems

This section asks you to respond to statements about your beliefs and perceptions around the growing significance that digital technologies play in modelling products, processes and physical systems in your engineering teaching. These technologies include Computer Aided Engineering (CAE), Artificial Intelligence (AI) and Product Lifecycle Management (PLM), among many others.

1. It is important that I invest more time and effort to use digital technologies to model engineering problems in my teaching
2. I am confident that using digital technologies to model engineering problems will improve future graduate capabilities
3. My leadership team expects me to use digital technologies to model engineering problems in my teaching
4. Many of my academic peers are actively implementing digital technologies to model engineering problems in their teaching
5. I am confident in my abilities to use digital technologies to model engineering problems in my teaching
6. I am provided the necessary support to use digital technologies to model engineering problems in my teaching
7. My institution rewards me for using digital technologies to model engineering problems in my teaching
8. I intend to invest more time and effort into using digital technologies to model engineering problems within the next year

Q28: Professional development as an engineering educator - Part 1

This section asks you to respond to statements about your beliefs, attitudes and perceptions concerning professional development as an engineering educator.

1. It is important that I regularly spend time investigating what other universities around the world are doing in my area of teaching
2. Being aware of emerging and innovative education initiatives is important to my development as an engineering educator
3. I believe that understanding non-engineering bodies of knowledge (e.g. education, psychology...) is important
4. It is important that I spend time developing my understanding of non-engineering bodies of knowledge as an engineering educator
5. Learning how to take risks in teaching and learning practice is an important ability in my professional development as an engineering educator
6. Being good at managing risks is an important capability for leaders in engineering education
7. Learning to be persuasive is an important skill to develop for me as an engineering educator
8. My leadership encourages me to take calculated risks in developing myself as an engineering educator
9. My leadership actively encourages me to work with other engineering academic educators outside my institution
10. My leadership actively encourages me to look globally for evidence of best practice to support my development as an engineering educator

Q29: Professional development as an engineering educator - Part 2

This section asks you to respond to statements about your abilities, intentions and perceived constraints to your professional development as an engineering educator.

1. My leadership actively encourages me to pitch innovative ideas to them to enhance my development as an engineering educator
2. My leadership believes that my development as an engineering educator is as important as my development as an engineering researcher
3. The ability to act decisively under uncertainty is one of my strongest skills as an engineering educator
4. I am confident in my abilities to keep on top of global trends in engineering education
5. I am confident in my abilities to innovate within my role as an engineering educator
6. I am confident in my abilities to read across non-engineering domains in developing my knowledge as an engineering educator
7. Next year, I intend to spend more time developing my role as an engineering educator
8. I intend to pursue academic promotion based on a strong emphasis on my role as an engineering educator in the next year or two
9. Next year, I intend to commit more time and effort investigating global issues and trends in engineering education
10. I plan on attending an engineering education conference within the next 2 years

Q30: The two most important barriers for me to innovate within my role as an engineering educator are:

Student dissatisfaction; Impact on promotion; Time taken away from research; Lack of available funding; Other

Q31: A free text option for ‘Other’
Q32: My preferred academic role would be a:

Teaching role; Teaching and research role; Research role

6.5 Appendix E: Organisation of Survey