Learning Engineering: experiences and opinions of learning to become an engineer

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Introduction

This paper presents findings of a research project conducted in a relatively small School of Engineering which has recently been growing in size, and developing new programme offerings and additional qualification pathways. The student cohort has been diversifying in its cultural background and gender mix. Most domestic students have been taught through the New Zealand national curriculum which increasingly emphasises learner centredness, shared learning, reflective practice, relevance, inquiry and critical thinking (Ministry of Education, 2007). The senior leadership team recognised that these changes in school experiences require adaptation to ensure continuing good outcomes for learners and the School. It further recognised that the tertiary education sector, including engineering education, has been moving away from teacher centred approaches. The School is starting to see an increase in project based learning, although lecturing is still a major focus for the teaching of fundamental knowledge and theory.

To build an understanding of how students experience learning to be engineers, and to provide a baseline for measuring change, a research study began in late 2018 to investigate perceptions of, and opinions about, learning among students and staff in the School. This paper reports on initial findings from students, related to two research questions: “How do students perceive different forms of learning and assessment”; and “What do students expect and need in their learning experience?”.

Evaluation of Learning & Teaching

Many, if not most, universities have some form of student evaluation of teaching. Richardson (2005) reviews the literature on student evaluation instruments. He notes that two approaches are common, either: evaluation at the end of a course and which is specific to that course, its content and the teaching of it; or post-degree evaluation after the completion of the programme of study. The latter is sometimes implemented within First Destinations surveys of recent graduates (Ramsden, 1991; Social Research Centre, n.d.).

The approach taken in this research differs from both post-course and post-degree evaluations in terms of when and who could complete the survey. Students studying in all years of the undergraduate engineering degree were invited to participate. The survey was conducted during the academic year rather than at the completion of studies. The respondents were therefore at different points in their studies, dependent on their year of study. Further, the survey instrument is contextualised to the design of the engineering degree at the University of Waikato. Questions targeted different areas of the degree, such as maths & computing, but deliberately did not ask students to address their experience in individual courses. There was a focus on student experience rather than consumer satisfaction (Richardson, 2005) in the question design.

Data collection

Data were collected from students through two methods, namely, a questionnaire and semi-structured individual interviews.

All students enrolled in one of the Bachelor of Engineering programmes in the School were sent an email inviting them to complete an anonymous online survey. Students in all four years of the degree received the invite. As the research focus is the experience of students learning to be engineers, students who were enrolled in engineering courses but were not enrolled in the BEng (Hons) were excluded from the data collection. The survey remained open for 5 weeks in the middle of the second semester of 2018. After the initial email asking students to complete the questionnaire, a further 2 reminders were sent.

The survey was divided into 5 sections. The first section sought demographic and background data including age, ethnicity, reasons for, and influences on, studying engineering. The next three sections grouped the taught courses into three broad types:

1. Mathematics & Computing courses
1. Engineering Science/Fundamentals courses
2. Design, Projects, Society and Sustainability courses

In these sections, students were asked to indicate on a Likert scale their agreement with statements about courses of that particular type, for example, Maths & Computing courses. These statements asked about the relevance of such courses to becoming an engineer, how well they linked to other courses, the effectiveness of teaching styles, whether they felt that the assessments accurately reflected their ability, the opportunities to analyse and understand real engineering problems, to be creative and innovative and to develop skills related to teamwork and cultural understanding. The statements in each section were similar but had differences relating to the section context. The respondents were then asked to comment on one of their responses to the preceding Likert scale questions. They were also given an opportunity to make any further comments on that section. The final section asked questions about how their overall programme of study was helping them become engineers.

At the end of the survey, students were asked if they would be prepared to take part in a face to face interview. Students were invited to interviews at the annual Design Show which took place during this period. In total thirteen semi-structured interviews with students were conducted. These were recorded and then transcribed prior to analysis.

The interview asked about:

- expectations and experience of studying to be an engineer;
- which parts of their course were useful or otherwise;
- what styles of teaching and learning, for example, lectures, labs, and tutorials, they thought were most useful and why;
- what assessment types were more or less useful and why;
- the qualities of a good teacher;
- inclusion;
- and their knowledge of the Washington Accord.

For this last question, a copy of the 12 graduate attributes from the Washington Accord was provided to the interviewee and their explicit and implicit awareness and understanding of the attributes and Accord were explored.

Data Analysis

This paper focuses on two of the research questions central to the study. These are, “What are the learning needs and expectations of students from their own perspectives?” and “How do students perceive different forms of learning and assessment?”. To answer these questions, we used a grounded theory methodology (Crotty, 1998) to build understanding from the data and generate further questions.

The survey and the interviews yielded a significant amount of data. The questionnaire was sent to 650 students and received responses from 310 students. The data were cleaned and validated to remove incomplete responses and responses from those who were not majoring

in one of the BEng programmes. This resulted in 229 valid responses which is a 35% response rate.

The survey and interview data were loaded into NVivo (QSR International, n.d.), a software tool that supports data organisation and analysis in qualitative and mixed methods research. The qualitative data were examined, thematically coded (Braun & Clarke, 2006), and interpreted. A number of rounds of coding took place to refine, expand and link themes emerging from the data. Illustrative quotes were identified as the analysis proceeded to help "tell the story" of learning to be an engineer in the School.

Results & Discussion

A comparison of the demography of the respondents with that of the student population in the School showed a close alignment across multiple dimensions. These dimensions include, the programme of study, (civil, mechanical, electrical, etc.), year of study, gender, ethnicity and age. Nine ethnic groupings were identified and while most groupings were proportionate compared to the School enrolment statistics, we found that Middle Eastern, Indian and Pasifika students were underrepresented in the survey responses.

The data analysis revealed themes of common or related experiences and perceptions of learning to be an engineer. Eleven major or high level themes (Table 1) and forty sub-themes were identified during the analysis.

Table 1: Themes identified during data analysis

Themes	
Assessment	Programme and courses
Engagement	Relationships
Identity	Relevance
Inclusion	Teaching
Learning	Washington Accord
Motivation	

Relevance was a cross-cutting theme which was linked especially with assessment, content, teaching and purpose.

Three key findings that stood out are that students want:

- Assessment that is practical and relevant
- Learning that is relevant to their future
- Teaching that is interactive and engaging

These key findings were prevalent throughout the data. In the survey, students were asked questions related to three groupings of courses, namely, "Mathematics & Computing", "Engineering Science/Fundamentals", and "Design, Projects, Society and Sustainability" courses. While there were differences evident between these groupings in the responses, it was clear that the three key findings were applicable across all course groupings.

Assessment

When respondents discussed assessment, they talked about the connection to what was being taught, the frequency and quantity of assessment, and the methods of assessment.

Students said that some assessments seemed disconnected from what had been taught or the way that it had been taught, suggesting possible lack of constructive alignment (Biggs & Tang, 2011) in some cases. Questions in tests were sometimes framed in different ways from examples used in class.

The amount of assessment that a student is required to do was frequently mentioned. Students recognised that regular assessment distributed across a semester can be beneficial and help them gauge how their learning is progressing. At the same time they indicated that the volume of assessment currently experienced has a negative impact on their learning (Quote 1). They also believed it impeded their ability to demonstrate the quality of their learning. Assessments were not completed to the best of their ability because of the pressure to move on to complete further assessments. A related factor is a disproportionate weighting in relation to effort required, i.e. many 'small' assessments that take several hours to complete but are only worth a very small part of the overall grade.

> *"The assessments are not only difficult, but many occur at the same time. I would recommend that lecturers actually communicate with each other so they don't bombard students with an unreasonable and impractical amount of work. If assessments were more spread out and students were given more time, students would actually benefit more as there would be more time to truly grasp the content and they would be able to do their best in assignments/tests/exams etc."*
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> **Quote 1: S01**

A range of assessment types is used in the School including lab reports, in-class tests, tutorial problems, project designs and reports, and exams. Students appreciated that variety in assessment type can assess different attributes and recognise individual strengths and weaknesses. They argued that currently exams promote memorisation and that they should be redesigned to be open book and use diverse problems as this will better demonstrate understanding (Quote 2). A further case was made for greater emphasis on practical and project based assessment.

> *"... there is no situation ever in the workplace where you would be shut in a room for 3 hours, with no resources or help from anyone, and told to complete sheets of calculations."*
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> **Quote 2: S02**

The data on assessment load prompted the research team to map the assessments for 1st year courses on a timeline. This indicated that students can be completing up to 9 assessments per week. At 2 or 3 points in the semester there could be multiple, substantial pieces of work due at the same time.

Learning

Students made many references to knowledge application and gaining personal and interpersonal skills. They appreciated the way that placements and design projects facilitate authentic learning with real world context and a number of students argued that this type of learning should increase. Students frequently noted the so-called soft skills that they gain from project work such as teamwork, communication, working under pressure, leadership, independence, creativity and time management (Quote 3). These are skills that they believe

can differentiate them in the job market and they were very positive about their value. In the interview data there is a general vagueness displayed about what the Washington Accord is, and what its stated graduate attributes are. The personal and interpersonal skills described above are all essential parts of the Accord graduate attribute profiles, especially WA9 ‘Individual and Team Work’ and WA10 ‘Communication’ (International Engineering Alliance, n.d.).

> *“The design projects have been relevant for becoming an engineer. They have taught not only technical skills, but also soft skills such as time management and teamwork which are vital for becoming a professional. I have also liked that the design project topics have been relevant to industry. My second year design project sparked an interest in the industry that I ended up working in for my summer placements and I have subsequently secured a graduate job in this field.”*
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> **Quote 3: S03**

Many students indicated that they couldn’t always see the relevance of the content of some courses, either to other courses in the programme or to its usefulness once they graduate. Maths courses in particular were identified as having a lack of clear relevance to other engineering courses. Students asked for maths courses to have examples more specific to engineering used in teaching. This includes being clear about how theory and solutions would be applied in an engineering context.

Teaching

The data indicates that students are aware of what they like and don’t like about teaching and how this affects their learning. Regular and prompt feedback, interactive teaching, friendly and accessible teachers, and teaching that links learning to real world applications are all things that students appreciated. They viewed feedback as essential to a good learning experience and argued that it needed to be timely. In terms of teacher accessibility, students recognised that staff have other pressures such as research, but they felt that staff and the School need to address this to make sure that teaching is also a priority. Asking questions and getting support is not something that can always be done at the end of lectures or during office hours.

Overall, engineering students who participated in this study like teaching that is clearly relevant and makes connections to industry or other parts of the degree. They recognised that they may be learning something now which will be useful later but found it frustrating when the purpose of learning something is unclear. They asked that teachers take the time to make those connections more explicit (Quote 4). This supports one of Malcolm Knowles assumptions of andragogy, namely that adults need to know why they are learning something in order to fully engage with it (Merriam, Caffarella, & Baumgartner, 2006).

> *“Maybe teachers could explain more often how what we're learning applies to the real world so that we know we're not just learning something for the sake of it. It wouldn't have to be a long explanation, just a brief one. e.g. "Today we're learning about differential equations. In engineering this is used for blah blah blah"*
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> **Quote 4: S04**

Students mentioned that some teachers had a very passive teaching style, with little or no opportunity for the students to do anything except take notes. This form of transmissive teaching as the converse of the interactive teaching that students said they appreciated.

Students suggested that staff should receive more support in regards to developing their teaching skills (Quote 5).

> *"I've always been surprised, here at university, where, you know, all the lecturers are, in their own right, highly qualified and experienced and doctorates and professors and so-on, but a lot of them don't have any teaching credit whatsoever. And, I am not convinced that just being smart qualifies you to be a teacher. Even if they don't have to do a diploma in teaching, just someone give them some kind of help."*
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> **Quote 5: S05**

Conclusions

Understanding the current student experience of becoming an engineer in a School of Engineering is important during a period of change. This analysis of data from Bachelor of Engineering students in all years of study is providing a baseline of experience and will allow later comparative study.

Students provided measured and thoughtful data in the qualitative elements of the data. Assessment, learning, and teaching are key elements of formal education and this paper has focused on the student responses in these areas. The analysis identified "relevance" as a recurring and cross-cutting theme in the data when students discussed assessment, learning, and teaching. This included assessments not aligning with the taught materials or the outcome being assessed. For learning and teaching, relevance was described in terms of content not connecting to, or making apparent, real world application. For some courses there was also a lack of visibility of the connection between learning in one course and its usefulness in later courses. There should be opportunities while teaching to make such connections more explicit.

The quantity and frequency of assessment may be reducing a student's ability to demonstrate their knowledge and understanding across courses. This is compounded when the weighting of assessments is disproportionate to the effort required for completion. Students didn't make a case for less assessment for the sake of less work. In fact there was a recognition that regular assessment was beneficial for learning. There is a need to balance assessment load so that it allows regular opportunity for meaningful feedback without overloading students to the point where they are unable to properly demonstrate their learning and ability.

Learning with design and project based learning methodologies is valued by students and is seen as being relevant to real world and work based engineering. Besides core engineering skills, courses with these approaches are recognised as developing high levels of competence in teamwork, communication, leadership and other allied skills. Students value these skills plus the authentic and contextualised learning that design and project learning offers.

Teaching styles that are transmissive and focus on student note-taking are viewed negatively. Students prefer interactive teaching and argue staff should be supported to develop good teaching practices where necessary. There is an acceptance that teaching staff have other workload besides teaching, however, this should not be allowed to reduce learning opportunities. Prompt and regular feedback on learning is seen as essential. Besides post hoc feedback on assessment, students appreciate teachers who are accessible and approachable and willing to support their learning.

This paper reports on a broad brush analysis of the dataset as it relates to the student experience of learning to be an engineer. Related analysis and further data collection are allowing different perspectives to be explored, including the experience between each

teaching programme, and the experience of different ethnic, cultural and gender groups in the School.

References

Biggs, J. B., & Tang, C. (2011). *Teaching for quality learning at university : what the student does*. Maidenhead: Society for Research into Higher Education : Open University Press : McGraw-Hill Education.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. London: SAGE.

International Engineering Alliance. (n.d.). Washington Accord » International Engineering Alliance. Retrieved 12 August 2018, from http://www.ieagreements.org/accords/washington/

Merriam, S.B., Caffarella, R.S., Baumgartner, L.M., 2006. *Learning in Adulthood: A Comprehensive Guide*, 3rd ed. John Wiley & Sons, Incorporated, Hoboken, United States.

Ministry of Education. (2007). *The New Zealand Curriculum for English-medium teaching and learning in years 1-13*. Wellington: The Ministry of Education by Learning Media.

QSR International. (n.d.). NVivo qualitative data analysis software | QSR International. Retrieved 5 September 2019, from https://www.qsrinternational.com/nvivo/home

Ramsden, P. (1991). A performance indicator of teaching quality in higher education: The Course Experience Questionnaire. *Studies in Higher Education, 16*(2), 129–150. https://doi.org/10.1080/03075079112331382944

Richardson, J. T. E. (2005). Instruments for obtaining student feedback: A review of the literature. *Assessment & Evaluation in Higher Education, 30*(4), 387–415. https://doi.org/10.1080/02602930500099193

Social Research Centre. (n.d.). Higher education study experience data. Retrieved 25 August 2019, from Quality Indicators for Learning and Teaching website: https://www.qilt.edu.au/about-this-site/graduate-satisfaction