Co-designing an engineering professional practice program with students

1st Timothy Boye
University of Technology Sydney
Sydney, Australia
0000-0001-8880-6073

2nd Tania Machet
University of Technology Sydney
Sydney, Australia
0000-0003-1963-898X

3rd Ria Narai
University of Technology Sydney
Sydney, Australia
ria.narai@student.uts.edu.au

***Abstract*—To most students the internal machinations of the university are a black box, very rarely are they permitted to see behind the curtain. While in many areas academia has started to move away from the sage-on-the-stage mentality, much of what is done still does not involve the students' voice. While they have the opportunity to provide feedback on individual subjects, the structure of students' whole degrees are still the domain of the sage.**

At the University of Technology Sydney (UTS) we are reviewing our professional practice program for engineering. This program sees students complete professional experience activities such as internships, reflections and professional skill development in order to give students the opportunity to develop as professionals. While the program is well received by most stakeholders, it has remained largely the same for some time. Changes in the Higher Education sector, changing student needs and learning from the COVID-19 disruption have resulted in a review looking to redevelop the program.

Typically a program review would be an opaque process for students if they were aware of it at all. However, UTS sought to bring students into the program development from an early stage. Engineering and IT students from any year of study were invited to apply to join a seven-week co-design studio over their Summer semester to reimagine professional practice at UTS. They were taken through the design thinking process to imagine a future program that meets the needs of all stakeholders. Students worked through empathising with past and current students, program academics, Work-Integrated Learning (WIL) experts, industry professionals and others they identified as important stakeholders. Additionally, the students completed independent research on context topics they identified as critical to understanding the space.

The results of the project were that students identified three key foci for their program:

- **Supporting the development of a diverse student cohort**
- **Improving the feedback loop between students, industry, and the University**
- **Fostering connection(s) between the University and industry**

To meet these aims the students proposed innovative solutions including a degree structure with an exit point for a lower qualification should a student not need the full qualification, and a flexi-points system to provide students access to a flexible professional development scheme tailored to each students' needs.

Throughout the studio the students independently developed both insights and ideas that had previously been raised by the University and new insights and ideas that the University had not considered. They developed their design thinking, professional practice, complex problem solving skills, and expressed an appreciation for the chance to better understand how and why the University works behind the scenes. From the perspective of subject designers, the process and engagement of students reinvigorated the academics affected by a long COVID-19 disruption that had seen diminished engagement from students.

This process significantly benefited all involved through the development of skills and knowledge in students, the reinvigoration of academic staff, and the development of confirmatory and new insights and ideas for the University. This innovative practice will be broadened and continued at UTS and the co-design processes it supported as the norm rather than the exception when redeveloping course content and program structures.

***Index Terms*—Engineering Education, Co-design**

I. Introduction

To most students the internal machinations of the university are a black box, very rarely are they permitted to see behind the curtain. While in many areas we have started to move away from the sage-on-the-stage mentality, much of what is done does not involve the students' voice, this in spite of the acknowledged value of student input into individual study unit design (for example [1]).

Engineering and IT degrees[1] are increasingly diversifying and specialising as the field rapidly changes. How universities develop and differentiate their degrees spans a wide range of considerations including accreditation bodies, attracting desired student cohorts, national priorities, funding regimes and market competition. At the University of Technology Sydney (UTS), an urban university in Sydney Australia, we offer accredited engineering and IT degrees for local and international students, competing with three universities in close proximity as well as nationally and internationally to attract students and deliver high quality teaching and education. A significant differentiator for our undergraduate degrees has been a professional practice program that is included in the course structure allowing students to graduate with a Diploma in Professional Practice as well as their undergraduate degree.

[1]In this paper we use the following terminology:

Subject: an individual unit of study, typically 12-weeks in length. A full-time student typically undertakes four subjects per semester and eight subjects per year.

Program: a series of related subjects linked together within a degree, these include each major, as well as a core program for all engineers, and the professional practice program discussed in this paper.

Degree: an undergraduate level qualification, in our case a Bachelor of Engineering and a Bachelor of Science in Information Technology.

Diploma: a vocational level qualification typically completed in 12-months, in our case a Diploma of Professional Practice.

This program sees students complete professional experience activities such as internships, reflections, and professional skill development in order to give students the opportunity to develop as professionals. While the program is well received by most stakeholders changes in the higher education sector, changing student needs, and learning from the COVID-19 disruption have resulted in a review aimed to redevelop the program to meet the changing environment.

Typically, a program review would be an opaque process for students, if they were aware of it at all. However, the Faculty of Engineering and IT (FEIT) at UTS sought to bring students into the program development from an early stage. Engineering and IT students from any year of study were invited to apply to join a seven-week co-design studio over their Summer semester to reimagine professional practice at UTS. This studio aligned with the faculty approach of exposing students to authentic contexts for applying their developing knowledge and skills. Six students were taken through the Design Thinking process to imagine a future program that meets the needs of all stakeholders. They worked through activities empathising with past and current students, program academics, Work-Integrated Learning (WIL) experts, industry professionals, and others they identified as important stakeholders. Additionally, the students completed independent research on context topics they identified as critical to understanding the space.

This paper reports on the experience of offering an innovative, for-credit subject centred around an authentic co-design of an engineering and IT program. We found significant benefits to students and staff and provide suggestions on how to broaden and incorporate this learning.

II. Background

Co-design involves the participation of clients and consumers in the design of a solution that best meets their needs [2]. Steen et. al. [3] present a summary of the common benefits of co-design projects including: improved ideas generation, improved solution design which is a better fit for the clients, and better relationships between stakeholders.

Increasingly co-design skills are considered vital for the human-centred engineer. Previous work has suggested that opportunities to experience and practice co-design skills be integrated throughout the engineering curriculum to build these skills in the next generation of engineers [4].

Typically opportunities to develop co-design skills are included in the engineering curriculum through humanitarian engineering projects where students work with community to develop solutions to local problems [5]. However co-design has also been adopted in higher education to improve educational experiences for students where students are being included as design partners for their own learning experience, fostering a sense of ownership [1] [2]. The research on projects that involve students in co-creation, participatory design or co-design activities indicate that input from students before the delivery of any learning has positive benefits for student agency, the development of professional skills, the implementation of teaching innovations and resulting curriculum design [1] [6]. In engineering and IT these experiences can play double duty in providing students both an opportunity to shape their own education as well as co-design experience they can bring to their professional practice.

Student input into their education is often elicited through satisfaction surveys administered at a subject level. In co-design activities, however, students are actively engaged before teaching takes place and included in the subject design and feedback loop. Students may volunteer, undertake activities for credit or for payment [7]. The design of the student engagement differs depending on the ultimate goal of the activity. Often this goal is improved learning resources, subject design and/or improved student engagement. There are few studies reporting on student involved in co-design at a program level.

It has been recognised in the literature that involving students in the co-design process is transformative to their understanding of their own learning and to their engineering science, as well as providing an opportunity to apply their learned design skills in practice [6] [7]. Some students found learning about their engineering science to be more relevant and authentic when it focused on their own experiences [8]. According to [7, p. 8], “student co-creators report that co-creation might mean that they put in more time and effort, but they are willing to do so because of the benefits they experience when feeling more engaged and enjoying learning”. They cite a student interviewed for their research who believes that many students do not participate in such courses because they “see it as a lot of work” but that those students who do participate in co-creation “[do not] see it as a lot of work because they’re enjoying it”. [7] concluded that it was not only high achieving students who benefited, but that the greatest learning gains may have been achieved by students not otherwise doing as well, arguing that co-creation activities therefore present an opportunity as an inclusive practice.

The literature does recognise the challenge of designing and executing co-design activities. In the implementation of successful co-design activities, [2] emphasise the value of participation and communication, and suggest the establishment of communication channels that allow for fluid information exchange between students, academics, and any other participants in the co-design process. [8] point out that participation as a term is not clearly defined in this context and they highlight some drawbacks of student co-design activities. These include criticism of the power student participation in co-design can give to student views as well as the significant investment in time, energy and skill development that may be required of academic staff and students. [8] make the case that in other areas we develop student skills before we ask them to apply these and so suggest that students involved in co-design activities receive preparation and guidance.

The research clearly highlights the potential value of co-design and makes suggestions for how to successfully undertake a student co-design activity to be implemented when educators are considering changes to subjects. Drawing on this literature and considering how it could be applied to the co-design at a program level, we report on the implementation and results of such a project at UTS.

III. Case Study

A. Institutional Context

The University of Technology Sydney (UTS) has a long history of professional practice focused and industry connected education, particularly in engineering and IT. Our most recent teaching and learning strategy Learning.Futures sees Work-Integrated Learning (WIL) as a key area for development across the University, forming one of the primary pillars of the strategy. However, in engineering and IT WIL has been embedded for many years.

Local students in engineering are required to complete not just their Bachelor of Engineering but also a Diploma of Engineering Professional Practice alongside it. The diploma requires that students complete two six-month internships in industry, as well as preparation work prior to placement, WIL coursework while on placement, and reflection and review upon returning from placement. Domestic engineering students enrolled in a double degree and international students do not have to complete the diploma. However, Engineers Australia accreditation guidelines require a 12-week internship or equivalent professional development activities for undergraduate engineering degrees so these students are still required to complete a 12-week internship with a preparation subject and reflection and review subject either side. IT students can elect to complete an equivalent diploma with the primary difference being these students typically choose to complete a full-year in industry (rather than two six-month internships). The diploma and internship subjects across engineering and IT are what the faculty refers to as the "Professional Practice Program".

The Professional Practice Program was designed a number of years ago and, while it has seen minor improvements over time, it has largely remained the same. Exacerbated by the COVID-19 disruption, external factors have started to put pressure on the program to be redeveloped and renewed, to ensure the program is future-facing, competitive in the higher education market, and attractive to students. Some key pressures faced by the program are: the five year length of the full engineering program compared to the four year choices at competing universities, difficulties in sourcing enough placements for all students particularly during COVID-19 disruption, increasing number of students finding work from their first placement and losing desire to complete the second half of the diploma, and an increasing body of evidence from the WIL research indicating that more diverse experiences (as opposed to two long internships) could potentially be beneficial for students [9, p. 5].

Due to the changing external factors the faculty indicated a desire for a review of the program. It is typical for such a review and change process to be developed in-house and reviewed by industry representatives through industry advisory boards. However, the Professional Practice Program coordinator and a colleague with experience in co-design saw a need to bring the student voice into the conversation. Particularly considering that many of the factors driving the review were around student perception, interest, and ambition. Having identified a need to bring in the student voice to the review, a co-design studio was developed and pitched to the faculty.

B. Professional Practice Co-Design Studio

1) Studio Aims: While co-design can be an extracurricular process and activity for students, it was felt strongly that the students were giving back significantly to the University and thus should be provided with a benefit to the students beyond having a say in the process. The studio was developed around student autonomy to practice and use their engineering and IT skills, particularly their professional and transferable skills, in order to drive and complete the project and to obtain academic credit for their work. Through the studio, an aim was for students to develop a greater understanding of their own professional skills and career through reflection. It was hoped that students would be able to solidify their research, design thinking, and problem-solving skills in an authentic, non-technical, complex project.

2) Subject Content and Learning Outcomes: In both the engineering and IT degrees in FEIT students are introduced to the d.school design thinking process in the first year of their studies. Engineers and some IT students will practice this process again in second year and beyond as well as use other similar tools such as the Engineers Without Borders human-centred design process [10]. Given the students' prior exposure to the design thinking problem-solving framework and given the complex and human nature of the project this made the design thinking process an obvious choice to frame the studio.

The studio curriculum was designed to be very structured in the early weeks and stages as students find their feet, before being driven by students in the later stages based on where their project is and where it needs to go.

During the empathise stage, the first stage of the design thinking process, it was identified that there would need to be some content delivery to get students a basic understanding of the context in which they were working. For instance, talks on Work-Integrated Learning and future skills should be provided. In addition, organising various stakeholders of the program, such as academics and industry representatives, to come talk to the students would also be key.

The latter stages of the process were less structured around content and activities organised by the academics and more structured around student discussion and research using design thinking tools such as empathy maps, problem analysis, 'how might we' statements, etc.

3) Structure and Assessment: The faculty recognises that students may enter into professional service projects that can be considered to develop their skills toward identified learning outcomes and so provides capacity for these to be recognised for academic credit in a "Professional Service Project" subject. The required focus for this subject is around building on professional and service engagements of students and students are expected to demonstrate that they have explored and understood aspects of engineering and information technology culture and how these professions impact and interact with society, economy and the environment. The subject is graded with no marks, that is students receive a High Distinction, Distinction, Credit, Pass, or Fail but not a mark out of 100%, and it is based around the submission of a portfolio of work.

The studio was structured as a seven-week program. For the first six weeks, students were asked to attend two three-hour sessions on campus each week, where they worked with their peers and the academics on the project. Students were also required to work on the project and assessment outside of class. The final week was for finalising the project and assessments outside of class.

The students' assessable portfolio was developed not just around the project but also on the students' own professional development. There were five items students were to develop for the portfolio:

- An individual reflection on their own professional experience and experience of the professional practice program (where they had a personal experience of the program). This served two purposes: to begin the empathising stage of the project by collecting experiences of the current program and to have students consider their own professional experiences and how to further develop those.
- Individual background research presented orally and in a one-page handout. This served to divide the vast number of background context topics the students needed to investigate among themselves, to allow students to practice their research and presentation skills, and to push students to consider the project not just as a group but also individually.
- A group final presentation to stakeholders. This served to allow students to further develop their presentation skills, to demonstrate their work to stakeholders, and to receive feedback to include in their final report.
- A group final report. This served to allow students to develop their documentation skills and to provide stakeholders with a written report on the studio outcome.
- An individual reflection on learning from the studio. This served to have students consider their learning and the changes that occurred in their perceptions through the process.

As well as the portfolio items, students' grades were moderated by their contributions to the studio and group.

4) Student cohort: The studio cohort was relatively small with only six students, however, the cohort was interestingly quite diverse. The gender ratio of the cohort was one third women, the discipline makeup was half IT and half engineering, and the grade average entering the studio was one pass average, three credit averages, one distinction average and one high distinction average. Also of note was the industry experience of students with two students who had limited experience in industry, four students with up to one year experience in industry, and one student with three years experience. All bar one student had completed some or all of the professional practice program.

IV. Discussion

A. Student Learning Outcomes

Student engagement in the subject varied between participants but was overwhelmingly positive and each student committed the expected time and effort to the subject. This was expected given that students had a lighter load in Summer and each had elected to undertake this subject. The students in the subject all received passing grades which ranged from Pass to High Distinction. This clarified to us that the assessment structure allows for differentiating outcomes between students - an important factor for students themselves in their own motivation and also for the approach of the faculty which encourages this practice.

Students developed their design thinking, professional practice, complex problem solving skills, and expressed an appreciation for the chance to better understand how and why the university works behind the scenes. In their reflections, the students noted that the application of engineering and IT problem solving techniques that they had learnt in technical subjects to a non-technical context was novel to them and increased their understanding of their profession. There was particular appreciation for how the subject design exposed the complexity in the 'real world' problem. For example:

> "Using the Design Thinking process so fundamentally throughout this subject has helped me to not only understand it better, but also to see how it can be applied to a wider variety of projects ... I felt I learned from this subject how to apply Design Thinking to a different sort of project than the ones I usually do in IT." - Participant 1

In addition, while the initial stakeholder interviews and discussions were arranged by the teaching staff, some students took the agency and accountability for identifying and investigating other stakeholders they felt were important. This demonstrates a high level of learning and engagement with the design thinking process. This could be due to the time on task, running the co-design as a seven-week project provided increased opportunity for students to take this initiative as opposed to a structured co-design workshop and follow-up session.

B. Co-design Output

The results of the project were that our students identified three key foci for their revised program:

- Supporting the development of a diverse student cohort
- Improving the feedback loop between students, industry, and the university
- Fostering connection(s) between the university and industry

To meet these aims the students proposed innovative solutions including a degree structure with an exit point for a lower qualification should a student not need the full qualification, and a flexi-points system to provide students access to a flexible professional development scheme tailored to each students' needs.

Throughout the studio the students independently developed ideas that had previously been raised by the university such as improving connections with industry. They also proposed novel ideas such the 'early exit' path from the program which students justified as supporting their focus for developing a diverse student cohort.

A key learning activity for students was in presenting their results to academics and industry partners (some of whom had been involved in previous stakeholder discussions). The authentic nature of the project meant that the audience was listening for the output of the co-design activity rather than assessing an assignment and the students themselves were aware that some of the ideas on the proposal may be taken forward by those in the audience. This resulted in an engaged discussion and in some cases students were challenged on their findings allowing them to explain much of their reasoning and to improve their final submission report to take on board the authentic feedback and improve communication. We see this as an example of a valuable alignment of co-design output goals with learning outcomes (improved professional practice skills such as communication and use of feedback).

C. *Teaching Reflections*

From the perspective of subject designers, the process and engagement of students reinvigorated the academics affected by a long COVID-19 disruption that had seen diminished engagement from some students. We were surprised at the level of engagement and professionalism of the students who joined the studio and were impressed with the output of their project.

We found it interesting comparing this experience of a for-credit studio to a previous co-design activity we had run to redevelop a subject in our core engineering program. The latter activity being a two session workshop and follow-up activity which was not for academic credit. The for-credit full subject form of our co-design project appears to have both changed the demographics of the students and their ability to develop rich ideas. We speculate that the students felt they would get more out of the studio than a single extracurricular workshop and thus a more diverse range of students, particularly diverse grade average students, applied to join the studio. As well, the length of the studio gave students much more time to work on the project, including outside of class, leading to deeper engagement in the project and richer insights for the project. The timelines for implementing changes to programs are long and as such we could not include this stage of implementation and testing and feedback into the studio. Students will be invited to participate in further discussions on the changes as volunteers and will be kept informed of the outcomes of the program redesign.

V. CONCLUSION

Our case study for the co-design activity aimed at program redesign supported what was found in recent publication on the value of co-design at subject level. Students found the experience valuable and the context engaged them and allowed them to transform their understanding of their own learning and their professional practice. We believe that offering credit for these activities allowed us to attract a more diverse cohort and to engage them more fully in the activities. The semester long nature of the activity allowed for students to delve deeper into the problem of co-design and demonstrate agency in the process. We believe that co-design presents a relevant, complex, authentic context for engineering and IT students to develop professional practice skills and have demonstrated that this is the case for the design of undergraduate programs.

Future work will expand this co-design process to future curriculum reviews and look for ways to include an implementation and feedback loop to the students involved. We will also look to investigate further the ideas developed in applying engineering skills to complex non-engineering problems in a permanent for credit studio option for students.

ACKNOWLEDGMENT

We would like to acknowledge all the students who participated in the studio, as well as all the academics and industry representatives who gave up their time to join the studio as stakeholders. We would like to particularly thank our coauthor Ria who was a student in the studio and generously volunteered to co-design this paper with us.

REFERENCES

[1] P. Inguva et al., "Advancing experiential learning through participatory design," Education for Chemical Engineers, vol. 25, pp. 16–21, Oct. 2018, doi: 10.1016/j.ece.2018.10.001.

[2] G. Ribes-Giner, M. R. Perello-Marin, and O. Pantoja, "Co-creation in undergraduate engineering programs: Effects of communication and student participation," International Journal of Engineering Education, vol. 34, no. 1, pp. 236–247, 2018.

[3] M. Steen, M. Manschot, and N. De Koning, "Benefits of Co-design in Service Design Projects.", International Journal of Design, vol. 5, no. 2, Available: http://www.ijdesign.org/index.php/IJDesign/article/view/890/346, 2011.

[4] A. Mazzurco, S. Daniel, and J. Smith, "Development of Socio-Technical and Co-Design Expertise in Engineering Students," presented at the Research in Engineering Education Symposium, Cape Town, South Africa, 2019.

[5] S. Daniel and A. Mazzurco, "Development of a scenario-based instrument to assess co-design expertise in humanitarian engineering," European Journal of Engineering Education, vol. 45, no. 5, pp. 654–674, Sep. 2020, doi: 10.1080/03043797.2019.1704689.

[6] J. Wu et al., "Investigating Students' Learning Through Co-designing with Technology," J Sci Educ Technol, vol. 30, no. 4, pp. 529–538, Aug. 2021, doi: 10.1007/s10956-020-09897-7.

[7] T. Lubicz-Nawrocka and C. Bovill, "Do students experience transformation through co-creating curriculum in higher education?," Teaching in Higher Education, pp. 1–17, 2021, doi: 10.1080/13562517.2021.1928060.

[8] C. Bovill, K. Morss, and C. Bulley, "Should students participate in curriculum design? Discussion arising from a first year curriculum design project and a literature review," Pedagogical Research in Maximising Education, vol. 3, pp. 17–25, Apr. 2009, doi: https://eresearch.qmu.ac.uk/handle/20.500.12289/552.

[9] ACEN, “Responding to the Job Ready Graduates – Higher Education Reform Package 2020,” Australian Collaborative Education Network, Australia, 2020. [Online]. Available: https://acen.edu.au/responding-to-the-job-ready-graduates-higher-education-reform-package-2020/
[10] Engineers Without Borders, ”Technology Development Process”. [Online]. Available: https://ewb.org.au/project/technology-development/