33rd Annual Conference of the Australasian Association for Engineering Education (AAEE 2022)
4 - 7 December 2022 – Sydney, NSW

Influences to student engineering identity development

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ABSTRACT

CONTEXT

Engineering identity has been repeatedly linked to the retention and success of engineering students and graduates. During tertiary education, professional engineering identity is driven by individual, social and systematic influences which can include personal values and demographics, industry experience, classroom activities, mentors, professional recognition, and technical skills. To better understand engineering identity, this research aims to capture self-identified influences to identity development from current undergraduate students and early career engineers (ECEs) and evaluate the importance of these influences.

PURPOSE

The study aims to understand how students and ECEs recognise their own professional identity and the importance of the influences during their undergraduate journey which contribute to its development.

APPROACH

Focus groups were conducted in September 2021 with students and ECEs who were attending or who had attended the Queensland University of Technology to complete a Bachelor of Engineering. The focus group questions explored their university experiences and the influences impacting their professional identity development. Thematic analysis was then applied to identify identity themes and influences. This was then used to validate current literature and identify influences which occurred most frequently and provide insights into additional identity influences.

OUTCOMES

Participants identified a range of influences that they felt had contributed to their professional identity development within their university studies. The most discussed influences included real-world design projects, industry experiences, peer supports, technical knowledge and individual values and attributes. Cocurricular experiences, such as involvement with student clubs and international exchange programs, was also identified as a positive influence, however this has not been previously recognised in literature as an influence to engineering identity development and should be explored further to capture this impact comprehensively.

CONCLUSIONS

Some professional identity influences recognised by students and ECEs were consistent with current literature, and design projects and engineering experiences such as WIL and co-curriculum experiences were found to have the greatest impact. The latter provides a unique perspective into student perceptions of their own identity development and can be used to further support and facilitate positive identity development strategies for engineering undergraduates.

KEYWORDS

Professional identity, engineering education, identity development

Introduction

Numerous definitions for professional identity (PI) exist within the engineering undergraduate and professional spheres (Morelock, 2017), however comprehensively defining this identity falls outside the scope of this paper. For the purposes of this paper, engineering PI encompasses the holistic and continuing development of engineers. The development of this identity is driven by influences which lead a person to identify as an engineer (Steinke, 2017; Sturtevant & Wheeler, 2019; Tallman et al., 2019). The influences to this identity evolution include individual personal values and ethics, technical competency, academic success, leadership skills, work experiences and many others (Morelock, 2017; Nadelson et al., 2017).

Within engineering education, a strong PI has been linked to academic success, professional effectiveness, and retention as graduate engineers (Nadelson et al., 2017; Sachs, 2001). For engineering undergraduates, their PI journey can impact their sense of familiarity to the profession, relationships to peers, and technical self-confidence (Villanueva & Nadelson, 2017). Undergraduate identity has also been identified as a crucial bridge between higher education and future employment in Australia (Tomlinson and Jackson, 2019).

Given the evidence relating PI to student engagement in learning, persistence, achievement, effectiveness, professional success, and retention (Morelock, 2017; Neumeister & Rinker, 2006) there is justification for researching and attempting to better understand PI and identify the influences to its development. A better understanding of PI is needed to ensure engineering educators can better structure learning experiences to embed positive identity influences, thus ensuring graduates develop stronger PI and improve subsequent retention within industry.

To address this need, this study centres on the research question: *What influences contribute to student professional identity development in engineering undergraduates?*

Background

Student and graduate attrition

Retention and completion within higher education have been the subject of increased focus internationally in recent years. For engineering courses, five percent of students will drop out of university in their first year, with a further 20% leaving in their later years of enrolment (Australian Council of Engineering Deans., 2019). Similarly, and more significantly, many countries, including Australia have seen that within three years of graduation, up to 40% of engineering graduates are working outside the engineering profession and in ten years it increases to over 50% (Streveler, 2018). The reasons for this lack of retention both within undergraduate study and the engineering workforce are complex and not fully understood (Trevelyan, 2010), however PI is discussed as a major influence to this attrition (Huff, 2019; Watson, 2006).

Professional Identity Development

Numerous influences were identified within literature as being influential to PI development for undergraduate engineering students. These influences were reviewed and collated under several common themes which emerged during the literature review process: individual attributes and values, peer connections, classroom activities, design projects educators and academics, mentors, engineering experience, technical knowledge, and academic results. These have been captured in the Table 1 below.

Table 1: Themes and influences to undergraduate engineering professional identity development

Theme	Influence
T1: Individual Attributes and Values	Alignment of course with individual values (Fagan, 2016)
	Personal identity is a minority to typical engineering identity (Hinojosa, 2018; Verdin et al., 2019)

T2: Peer Connections	Relationship to peers (Interiano et al., 2019; Park et al., 2018)
T3: Classroom Activities	Engaging with students' personal value system through case studies and ethical challenges (Gwynne-Evans, 2018)
	Self-reflection and autoethnographic portfolios allowed students to receive peer and professional feedback, focus on professional communication and introspectively review their own accomplishments (Chen & Patel, 2019; Gaunkar & Mina, 2018; Kahn & Novoselich, 2019; Svyantek & McNair, 2015)
	Hands-on and practical learning experiences (Interiano et al., 2019; Ofori-Boadu et al., 2019)
	Framing and solving problems, tinkering, collaboration, analysis, design, and project management (Patrick et al., 2021)
T4: Design Projects	Design learning experiences when they involved supervisor and peer feedback (James, Svihla, Qiu, & Riley, 2018; Johnson & Ulseth, 2016; Won et al., 2017)
	Undertaking an independent design project (Kahn et al., 2019)
	Immersive summer course and challenge project (Welch-Devine et al., 2018)
	Participation in real world problems and projects (Tallman et al., 2019)
	Completing a capstone course (Parker, 2017)
T5: Educators and Academics	Relationship to faculty (Interiano et al., 2019; Park et al., 2018)
	Consultations with project supervisors (Kahn et al., 2019)
	Instructor preparation and teaching style (Ofori-Boadu et al., 2019)
T6: Mentors	Industry connections (Ofori-Boadu et al., 2019)
T7: Engineering Experiences	Academic and industry experience is integral to developing professional identity as it is able to facilitate and demonstrate examples of mentoring, refinement of professional skillsets, communication, management, professional socialization, accountability, ethics, feedback, diversity, and teamwork (Male & King, 2014; Ofori-Boadu et al., 2019; Spencer et al., 2018)
T8: Technical Knowledge	Skills acquisition (Park et al., 2018)
	Authentic knowledge (Interiano et al., 2019)
	Recognition of skills (Springer & Huang-Saad, 2020)
T9: Academic Results	Academic achievement (Fagan, 2016)

Many of the influences found discussed the presence of classroom activities and learning experiences as ways to build identity. This primarily focused on theoretical content and classroom experiences, industry experience, independent design projects and authentic, real-world applications. It is important to recognise that although classroom curriculum should be adapted to foster engineering identity, the university experience as a whole should also encompass and build identity for students. Involvement and the subsequent impact on identity in student clubs and societies, leadership roles, social sports, student exchanges, scholarships and success programs, and development opportunities are not well described in the literature. This creates a significant gap in understanding the holistic identity journey of engineering students.

Barriers to professional identity development

As influences exist which contribute to the evolution of PI, so too do barriers which inhibit PI development. Individual demographics, primarily minority attributes, were identified as major barriers. As engineering is typically a male-dominated industry, gender was most often identified. Female students are less likely to have a well-formed engineering identity, specifically, lacking perception of themselves as engineering professionals (Verdin et al., 2019). It is well documented that women in engineering are exposed to numerous impacts which may explain this phenomenon, such as an unwelcome atmosphere, experience of marginalisation, low representation rate of females, unequal development opportunities, different learning methods, work-life imbalance etc., (Badets, 2020; Fouad et al., 2017; Hernandez et al., 2017; Moè, 2020).

Hinojosa (2018) also identified additional barriers to STEM identity development including being from a lower SES background, a lack of STEM role models and being a first-generation university student.

By gaining a comprehensive understanding of these barriers, universities may better support students in the development of their PI. Interiano et al. (2019) notes that the ways students make meaning is individual and diverse, and future research is needed to explore the intrinsic diversity of identity development.

Method

Data Collection

Focus groups were held to confirm and validate the previously identified PI influences found in literature, determine the most frequently identified influences, and determine any additional influences. Focus groups were selected as they allowed for interactive participant discussion which facilitated rich conversation of various experiences. Seven focus groups, with a total of 25 participants, were conducted in September 2021 at the Queensland University of Technology (QUT). These groups were held around a large table to ensure inclusion, covered eleven open-ended questions, and averaged a length of 51 minutes. Ethics for these focus groups was approved by Human Research Ethics Committee at QUT, approval number 2021000288.

The focus group included eleven questions and this paper focused on the responses to two of these questions – "*what experiences have you had that have most influenced your development as an engineering professional?"* and "*what do you think is the biggest barrier to your development as an engineering professional?*". These questions were selected as they presented a broad overview of self-identified identity influences. Open-ended thematic analysis was first used to categorise influences into the overarching themes identified in Table 1. These were then further grouped into specific influences and additional influences were added to accommodate further findings.

Participants

Participants included undergraduate engineering students in their third or final year of study at QUT and ECEs (1 to 5 years post-graduation) who have completed an engineering degree at QUT. Student participants were identified through advertisement in engineering undergraduate courses. Two core units offered to third, and final year students were targeted as these units are undertaken by all engineering students. Advertisements were also included on several engineering student club social media pages. ECEs were contacted through professional contacts of the research team using LinkedIn and through QUT Alumni. An overview of the participant demographic data is included in Table 2.

Table 2: Participant demographics

	Count	Percent
Education		
Student Engineer	17	68%
Early Career Engineer	8	32%
Gender		
Male	7	28%
Female	18	72%

72% of the participants identified as female and it should be noted that this is not representative of a typical, male-dominated engineering cohort. However, it is well documented that undergraduate research can often be overrepresented by female participants (Dickinson et al., 2012). As this study looked to identify barriers to identity development, which are often gender related within engineering, this skew was considered acceptable, but further investigation is warranted.

Data Analysis

The audio from the seven focus groups was recorded and transcribed. The responses from the two questions which were the focus of this study equated to 14,218 words of data and 89 minutes of audio recording. These transcriptions were then analysed using structural coding within NVivo to confirm and validate the previously identified PI themes and influences in Table 1 and identify any additional influences. The transcripts were first coded against the overarching themes; T1 – T9.

These codes were then further examined to search for pre-determined influences. 17 of the 21 identified influences were recognised in this analysis. An additional theme, T10: co-curriculum experiences, and two associated influences, student clubs and international exchanges, were also identified in this process.

Results

Table 3 summarises the findings of this analysis through the frequency each theme and influence occurred. These findings show that T4 (design projects) and T7 (engineering experiences) were the most often discussed by participants as having an impact on their identity development followed by T1 (individual attributes and values) and T8 (technical knowledge).

Table 3: Summary of themes and influence frequency

Theme	Theme Frequency (out of 25 participants)	Influence	Influence Frequency (out of 25 participants)
T1: Individual Attributes and Values	12	Alignment of course with individual values	5
		Personal identity is a minority to typical engineering identity	7
T2: Peer Connections	6	Relationship to peers	6
T3: Classroom Activities	5	Engaging with students' personal value system through case studies and ethical challenges	0
		Self-reflection and autoethnographic portfolios allowed students to receive peer and professional feedback, focus on professional communication and introspectively review their own accomplishments	0
		Hands-on and practical learning experiences	3
		Framing and solving problems, tinkering, collaboration, analysis, design, and project management	2
T4: Design Projects	21	Design learning experiences were positively correlated to professional identity development.	7
		Undertaking an independent design project Kahn et al. (2019)	3
		Immersive summer course and challenge project	0
		Participation in real world problems and projects	7
		Completing a capstone course	4
T5: Educators and Academics	6	Relationship to faculty	4
		Consultations with project supervisors	0
		Instructor preparation and teaching style	2
T6: Mentors	2	Industry connections	2
T7: Engineering Experiences	22	Academic and industry experience is integral to developing professional identity as it is able to facilitate and demonstrate examples of mentoring, refinement of professional skillsets, communication, management, professional socialization, accountability, ethics, feedback, diversity, and teamwork	22
T8: Technical Knowledge	12	Skills acquisition	4
		Authentic knowledge	1

		Recognition of skills	7
T9: Academic Results	3	Academic achievement led to the creation of a professional image of themselves for students	3
Additional theme: T10: Co-curriculum Experiences	7	**Additional influence:** Student clubs	5
		Additional influence: International exchanges	2

Engineering Experiences

T7 (engineering experiences) was the most frequency identified theme, specifically the influence of academic and industry experience. This was expected as the impact of work integrated learning on identity is well documented within engineering (Dominguez et al., 2019; Jackson, 2017). These real-world opportunities provide students with experiences to increase their employability, project management, writing and presenting skills and project management (Hogan, 2012). Engineering experiences also allow student to gain enthusiasm and confidence when solving engineering problems (Foong & Guthrie, 2006). Some examples of work placement contribution include:

> *When I was doing my work placement, I learned more about the process to becoming an engineer. Like in Queensland you can get your RPEQ and that, kind of, maybe more visualise what the path to becoming an engineer would look like, for me at least.*
>
> *My work experience in particular has really solidified that decision, [to be an engineer]*

Design Projects

T4 (design projects), and specifically design learning experiences and real-world projects were also well represented. Examples include:

> *I feel like having it all come together from all those little bits that you learn throughout the semester and just putting it all into one thing, I actually really enjoyed that and having a whole project done at the end.*
>
> *You're actually working on a mock version of a real-life project and things like that. So, I feel like having those units has made me feel like I'm actually doing something that would be somewhat real life*
>
> *When we get given a project to do and work through for the whole semester, that feels very much like what an engineer would do. I think it's things like that and using the proper terminology that make it seem like it's an engineering project.*

Project based learning and design projects have demonstrated ability to improve students' understanding of professional and ethical responsibility and enhance student preparation to practice engineering design (Bielefeldt & Paterson, 2009) and in turn progressing identity development.

Personal Identity

Within T1 (individual attributes and values), the clash between personal gender identity to the typical engineering male identity, was discussed as barrier to identity development for participants.

> *I don't remember having a lot of women lecturers or tutors. A lot of the people or women coming into STEM don't get to see what women can look up to, become, aspire to be. No-one really shows us that.*
>
> *I don't know about all minority groups, but I'm female, so I have that experience. It wasn't always easy.*

Tomer and Mishra (2016) emphasises that PI development is highly personal and found that respondents of different genders can adopt vastly different journeys towards building their identity. The link between professional and personal identity holds clear significance and is worth further exploration.

Technical Knowledge

T8 (technical knowledge) was discussed most frequently regarding the influences of skills acquisition and recognition, of which both contribute to an image of oneself as an engineer (Morelock, 2017; Nadelson et al., 2017).

I've done a lot of work going out to schools and doing engineering workshops with them and stuff like that. Then when you go, sometimes students will be like, whoa, how do you know all this stuff? Then it makes you realise that, through the degree, I've actually learnt a lot and accumulated a lot of knowledge that I wouldn't otherwise have.

Additional theme: Co-curriculum experiences

Through this analysis an additional theme was observed around co-curriculum experiences. This was not previously captured as a theme, however, does incorporate key aspects of numerous other themes i.e., peer connections, design projects, mentors, engineering experiences, and technical knowledges. This theme included the influences of student clubs and societies and international exchanges. This influence has not been well linked to identity development and provides an important aspect of better understanding the student identity journey. Examples include:

I think, one of the things would be going to industry events and [club] events. When you get to hear from engineers who are actually practicing in the real world, what they actually do in their job and you're like, oh, sometimes I do a bit of that kind of stuff. It's like, oh, that's cool.

Other Influences

Similarly, T3 (classroom activities), particularly the influence of hands-on and practical learning experiences, provided students with a practical opportunity to undertake engineering work.

Some of the projects that are very on-hand, for example at QUT first year engineering they make us build a crane of some sort. I prefer to do that kind of work. I prefer to do work with my hands because then I can see it manifest itself in front of me as opposed to writing down numbers on a paper.

T2 (peer connections) were discussed very positively by respondents and identified as a significant influence on academic success.

I don't think I could have got through uni without having friends to help with assignments.

I'd have not gone through [unit] without them - I literally would have failed that every time.

Conversely, T5 (educators and academics) and T6 (mentors) were both presented as barriers to participant development, particularly to do with teaching style and availability of staff.

With some tutors and lecturers, their style matches your learning style a bit more, so it's easier to understand when they're trying to help you. Whereas from others that your styles don't match up; they don't always find a different way to explain the thing that they're trying to explain to you.

They didn't really have the time to mentor you and so it was really hard to get in there and learn that technical stuff.

Finally, T9 (academic results) was the least discussed and only as a barrier to study progression, however due to the limited occurrences is not a significant finding.

I think the second time I failed [unit] I was like do I really want to be an engineer anymore? You have doubts.

Several influences were not present in these transcripts including, case studies and ethical challenges, self-reflection and autoethnographic portfolios, immersive summer course and challenge projects and consultations with project supervisors. This may be due the specificity of these influences, however, it should be noted that this analysis only explored two of eleven questions covered in the focus group and thus this data may not present a complete understanding. It should also be noted that this study only included participants from QUT, and participants self-identified their identity influences. These factors create some limitations to the application of the findings from this data.

Conclusion

It has been established that engineering PI plays a significant role in retaining student, graduate and professional engineers (Crosthwaite, 2019). We found that design projects and engineering experiences were the most significant factors contributing to student PI development. The theme of co-curriculum experiences (student clubs, international exchanges) was also identified, and this presents an important aspect in understanding students' identity journey and as such an avenue for further research. This research provides a unique perspective into student perceptions of their own identity development and can be used to further support and facilitate positive identity development strategies for engineering undergraduates.

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