Redefining Student Identity in Engineering Education:
Student Engineers

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ABSTRACT

CONTEXT

Effectively educating the new generation of engineering students requires educators to adapt to their unique generational traits, particularly in welcoming and motivating first-year students. However, the review process has revealed a dearth of scholarly papers on first-year engineering students, particularly within the Australian context.

PURPOSE OR GOAL

This study aims to gain insight into innovative approaches in the first engineering unit and their impacts on improving the retention rate among first-year students over successive years. Considering the demand of this new cohort during the transition process, innovative approaches tailored to their learning preferences and consistently refined each semester in response to valuable student feedback have been implemented. These encompass "Be Ready as a Student Engineer from Day 1" through hands-on workshops, "Engineering Education as Citizenship Education" via Personal Development modules aligned with UN Sustainable Development Goals, and "Transition to University" facilitated by a Continuous Support and Monitoring System.

APPROACH OR METHODOLOGY/METHODS

The research has been conducted at Macquarie University, Australia over the past two years. Data collection occurred in 2022, 2023, and 2024, incorporating both primary and secondary sources. Primary data entails students' feedback obtained through anonymous end-of-semester unit surveys (LEU), while secondary data comprises information from the university database, including enrolment and withdrawal rates over two distinct years.

ACTUAL OR ANTICIPATED OUTCOMES

Students have expressed positive feedback in the surveys regarding these approaches, emphasizing their role in fostering a sense of belonging to both the university and engineering studies. This contributes to a reduction in the risk of study discontinuation among students. Empirical evidence lends support to this claim, demonstrated by low withdrawal rates in 2022, 2023, and 2024 (1.5%, 1.6% and 0.27%). Self-management skills topics align with UN goals (Good health and well-being, Equalities, and Sustainable development) ensuring that the content remains current with global trends and aligns with the preferences of the new generation.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The research demonstrates the effectiveness of innovative practices in aligning with the needs of the new generation. Its design holds promise for broader application, extending beyond engineering to encompass educational research more broadly and beyond Australia.

KEYWORDS

Pedagogy, Gen Z, retention

Introduction

Context

Generation Z (Gen Z) is "the generation of people born in the late 1990s and early 2000s" (Webster's dictionary). By 2025, Gen Z is expected to comprise one-third of the Earth's population (Staglin, 2022). As many members of Gen Z begin their university education in the 2020s and the oldest start entering the workforce, the focus has shifted from Millennials to this emerging generation (Parry, 2020). This shift aims to enhance understanding and improve methods for teaching, supervising, leading, and collaborating with Gen Z.

Regarding education, it has been noted that Gen Z will arrive at university with distinct experiences and skill sets. Therefore, educators must adjust their teaching and learning methods to accommodate the unique characteristics of this new generation (Moore & Frazier, 2017).

Research gap

A review of scholarly articles on Generation Z engineering education was conducted across multiple research databases, including IEEE and Science Direct. A total of 62 conference and journal papers were identified and analyzed. These papers were then categorized by geographic region, as illustrated in Figure 1.
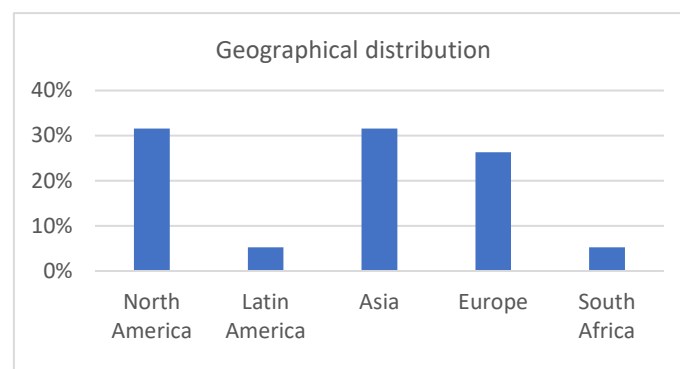

Figure 1: Geographical distribution of reviewed papers

Interestingly, Australia is taking 9% of world's top engineering universities and ranking fifth overall behind world leaders the United States, China, U.K and Germany (Digital, 2020). In Australia, the enrolment of engineering students has been reported to grow over the past period of 10-15 years (ACED, 2020; Crosthwaite, 2021). However, no studies have been found focusing on the engineering education of first-year Gen Z students in Australia.

Given the limited research on educating first-year Generation Z students, this study seeks to explore innovative methods tailored to their specific needs, which are currently being implemented in an engineering program at an Australian university. These approaches are designed to align with the unique characteristics of Gen Z, focusing particularly on welcoming and motivating first-year students. By enhancing student learning, improving the learning environment, and providing stronger support, these strategies aim to increase retention rates over time.

Research methodology

For first-year students, the first engineering unit is a critical introduction to the engineering discipline. Therefore, delivering a memorable and exciting start to the engineering curriculum is essential. To cater to this new generation of learners, research on their characteristics has been conducted. Consequently, innovative approaches aimed at fostering a supportive learning environment and enhancing the learning experience have been implemented.

The research is conducted within the first engineering unit of the engineering program (ENG1XXX: Introduction to Engineering) at the School of Engineering, Macquarie University, Australia, spanning the years 2022, 2023, and 2024.

The findings and results are gathered through both primary and secondary data sources involving freshers enrolled in the engineering programs. Primary data comprises feedback obtained from anonymous end-of-semester unit surveys (LEU) and other communication channels, while secondary data is sourced from the university database including enrolment and withdrawal rates over two distinct years.

Approaches and Results

Effectively educating the new generation of engineering students requires educators to adapt to their unique generational traits, particularly in welcoming and motivating first-year students. In this section, the authors will describe three different innovative approaches, "Be Ready as a Student Engineer from Day 1", "Engineering Education as Citizenship Education" via Personal Development modules aligned with UN Sustainable Development Goals, and "Transition to University" facilitated by a Continuous Support and Monitoring System. These are informed by a literature review on the transition process of this new cohort, as well as insights gained from valuable student feedback.

Be Ready as a Student Engineer from Day 1

Innovative 1: Report shows that 51% of Gen Z learn best by doing (Zimmer, 2015) and prefer observation or experiential practice (Vizcaya-Moreno & Pérez-Cañaveras, 2020). In alignment with the preference for hands-on learning, ENG1XXX is purposefully structured to offer students their initial hands-on engineering experience via practical workshops from the first day. These practical workshops cover a range of engineering disciplines at our school, including Technical Drawing, Arduino, Machining, Civil Engineering, and Software Design Logic. Figure 2 describes the activities at different workshops.

Figure 2: Examples of workshop artifacts

(From left to right: Civil, Arduino, and Machining)

In the workshops, students will simultaneously learn and create their prototyes. All hands-on skills aim to produce a student artifact by the end of the module, and as a first-year student, this is a rather memorable experience. All hands-on activities help establish active learning, which is a key element of engineering education. The workshops are both enjoyable and beneficial (some examples of positive comments are demonstrated below).

> _"The hands-on experience was very engaging and helpful in understanding certain concepts and ideas." "Practical with a hands-on experience. Definitely recommend." (LEU S1 2022)_

> _"In this unit I have understood the fundamentals of basic engineering skills it has really development my idea of engineering in both practically and theory." (LEU S1 2022)_

> _"Overall it was a good experience. It helped me think in a way which will help me in the future. The content was created to focus on the practicals which was very useful." (LEU S1 2023)_

Innovative 2: Furthermore, new students may either be eager to experience their chosen discipline or uncertain about their choice. To address this, students are given the opportunity to engage in two different specialized engineering workshops tailored to their interests through a preferential voting method. This fosters a sense of ownership in their learning and indirectly enhances the belonging sense to engineering and the institution from the first day.

These following evidence underscores that the diverse workshop designs enhance the learning environment by providing students with the opportunity to explore various engineering disciplines. By delving into different specializations, students gain insights that help guide their choice of their engineering trajectory. Evidence of enhancing students' learning experience by fitting their interest and practicality can be seen in LEU surveys.

> *"Allows students to explore and learn <u>different fields</u> of Engineering", "Structured well and were <u>a range of skills to suit each need</u>" (LEU S1 2022)*

> *"The unit was engaging and <u>tailored to my major/interest</u> well since we could choose what specific topics we would do." (LEU S1 2023)*

Engineering Education as Citizenship Education

Innovative 1: Self-management skills are mentioned to be the first step in a staircase of career and life possibilities (Walesh, 2012). However, the survey of Australian students in 2022 has shown that 78% of students claim to struggle with procrastination (Cundy, 2022). Many other universities worldwide have implemented support systems, such as self-management courses with a cognitive behaviour approach (Essen et al., 2004), or self-management tutorials (Gerhardt, 2007). Given the critical role of these skills, the authors have adopted an approach of integrating Personal Development modules into engineering education from the very first day at the university.

Self-management skills topics, including Purpose, Habit, Reflective Practice, Awareness, and Equity, Diversity and Inclusion (EDI) are chosen to align with *Engineering Your Future: an Australasian guide* (Self-management skills), and *UN goals* (Good health and well-being, and Equalities). To make the modules interesting and engaging, they are designed as open discussion-based podcasts to replace traditional lectures.

The design of these topics has shown a positive impact on students' learning performance. They have clearly indicated the improvements by applying these self-management skills in their learning and well-being.

> *"Very fun and engaging unit that is also helpful in getting people to improve their <u>everyday type of skill.</u>" (LEU S1 2023)*

Innovative 2: Gen Z is increasingly recognized as the sustainability generation, displaying heightened concerns for the well-being of the planet (First-Insight & Center, 2021). These facts highlight the outcomes of sustainability education for the current generation, as reflected in *Engineering Your Future: An Australasian Guide* (Sustainable Engineering) and *the United Nations' Sustainable Development Goals*. In alignment with these trends and our Faculty Strategic Framework 2022–2026, which emphasizes sustainability, we have designed a Sustainable Engineering module tailored for first-year students. This ensures that the content remains relevant to global trends and resonates with the preferences of the new generation.

> *"Please continue to encourage students to ponder on <u>their role in the world. Very much needed</u>" (LEU S1 2022)*

Transition to University: Continuous Support and Monitoring System

The transition to university is considered a pivotal moment for new students, often accompanied by mixed emotions such as excitement and stress (Lee et al., 2023). Supporting students through transition to ensure their success in university is considered "everyone's business" (Kift, 2009). Higher education institutions have increasingly prioritized

improving student engagement and retention, emphasizing the heightened importance of successful student transitions into tertiary education contexts (Lin et al., 2023).

Students can provide their feedback in LEU surveys, which are conducted at the end of the semester. However, this timing prevents educators from offering timely support when needed. To address this, weekly general reflection tasks and anonymous surveys that can be completed at any time are implemented. These provide students with free-text platforms to share their thoughts and concerns at any time. With these measures, educators can provide timely support to students.

> "Thank you so much miss I can't tell you how <u>deeply grateful</u> I'm, I really appreciate it you, you're the best!" (Email from student showing their appreciation, 2023)

Outcomes

For first-year undergraduate students, fostering a sense of belonging to the university and their engineering studies is crucial to reducing the risk of discontinuation. As such, delivering a memorable and exciting start to the engineering curriculum is essential. Through the application of innovative approaches, students have attested that these methods have significantly enhanced their learning experience. These approaches have created a supportive learning environment and enriched the learning experience, aligning well with the needs of this new generation of learners.

The LEU surveys over the past two years have received very high response rates (Table 1), demonstrating the students' engagement with the unit.

Table 1: LEU response rates

Year	2022	2023	2024 (Semester 1)
Total of invitees	465	485	375
Number of responses	178	216	177
Percentage	38%	45%	47%

The results show high and improved scores for various criteria (Figure 3), with over 70% of students finding the unit engaging and willing to recommend it to others. These numbers improved in 2023 and 2024, with over 80% of students reporting engagement and 75% recommending the unit.
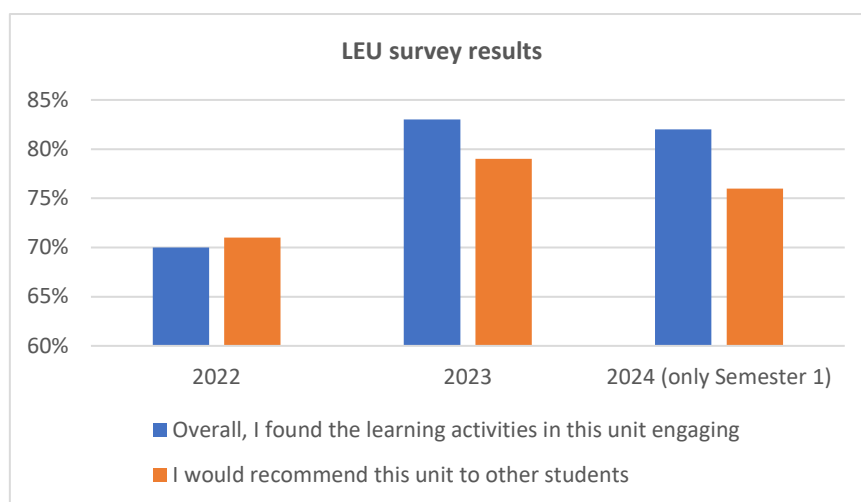

Figure 3: LEU criteria results

Some anonymous comments for the unit engagement:

> *"It was a very <u>enjoyable unit and a great introduction</u> for students starting in Engineering! I think the convener and staff have a great passion for trying their best to teach their students." (LEU S1 2023)*

> *"My experience with this unit was <u>amazing, I enjoyed</u> the environment, the content, the learning, and the tutors are also really helpful and friendly. I wouldn't change anything in particular." (LEU S1 2022)*

> *"This was a great core unit that had a <u>great engagement and entertaining workshops</u>." (LEU S2 2022)*

An example of unit retention influenced by student feedback can be seen in the following comment:

> *"I would <u>recommend</u> it for anyone interested in relation to anything to do with engineering."(LEU S1 2024)*

An example of retention success for the first-year cohort, acknowledged by the Faculty:

> *"I'm writing to say congratulations on the fantastic results for ENG1XXX this year. You and your team have really made a difference to students, and I think it is fantastic the work you have put in." (Email from Deputy Dean Education and Employability, 2023)*

Due to the high academic failure rate and attrition in the first year, these teaching approaches are implemented to decrease the risk of students discontinuing their studies. Empirical evidence supports this claim, as demonstrated by the very low withdrawal rates in the unit in 2022, 2023, and 2024 (Table 2).

Table 2: Withdrawal rates

Year	2022	2023	2024 (Semester 1)
Withdrawn rate	1.51%	1.65%	0.27%

Conclusion and Future Research

The paper illustrates innovative approaches aimed at better aligning with the needs of the first-year Gen Z engineering students. Research has been conducted in one Australian university from 2022 and has shown sustainably positive outcomes for students and the university. Three innovative teaching approaches have been applied. Firstly, students are offered various options to engage in hands-on engineering activities from the very first day. Secondly, to cultivate self-management skills, personal development modules are designed, aligned with UN themes, ensuring that the content remains current with global trends and resonates with the preferences of the new generation. Furthermore, educators provide timely proactive support to facilitate a successful transition for students through real-time platform.

Scholarly, this paper is the first one to explore in-depth the educational activities for first-year Gen Z engineering students and how institutions support their transition to university in Australia.

Gen Z is born after the internet and is a digital native (Turner, 2015). In light of the trend among Gen Z, the utilization of social media in the teaching and learning environment should be considered as a future-oriented approach, which has not been formally applied or considered in our research. A suggestion for future research is to investigate and develop a communication system for teaching and learning through social media, instant communication platforms, and integrated mobile smart devices to adapt to the lifestyle of the new generation.

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