

# Co-Evolution of Leadership and Knowledge: A Pilot Study on Advancing Engineering Education

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## ABSTRACT

### CONTEXT

Fostering a sense of belonging and prioritising community engagement among students is paramount to advance engineering education at the University of Sydney. This overarching goal has led to a pilot study with Biomedical Engineering (BME) cohorts, whereby, we support the development of a strong professional identity early on and offer leadership opportunities for penultimate year students. This project was carried out by a team consisting of unit coordinators, selected tutors, and an educational designer, and was funded by the Faculty Education Innovation Grant (2023).

### PURPOSE

The pilot initiative aims to address existing gaps by providing leadership opportunities and fostering a sense of belonging and professional identity by connecting different year cohorts in BME. It offers a platform for first year and third year students, through project-based learning with clinicians, to gain deeper insights into biomedical engineering, collaboration, and leadership.

### METHODOLOGY

The methodology strategically aligns students from both cohorts based on the cohort's size and project interests with strong emphasis on developing leadership skills. Learning activities span several weeks, focusing on BME industry discussions. Students engaged through written reflections and assessments. A pilot trial was conducted, and student feedback collected via voluntary anonymised surveys.

### OUTCOMES

The Phase 1 pilot study produced encouraging results. Program goal of shaping professional identities, was met with a 24% increase in first year students reportedly gaining insight and 68% finding relevance in the program. Third year mentors reported skill development and role satisfaction, and first year students noted improved teamwork and communication skills despite challenges. The program is expected to foster sense of belonging through mentorship, though this may develop over time.

### CONCLUSIONS/RECOMMENDATIONS

This innovative pilot program has quantitatively highlighted the benefits and challenges of collaborative learning between cohorts. Data indicated that first year students gained deeper insights into the biomedical engineering program, while third year students enhanced their team management and leadership skills. These findings provide valuable insights for refining Phase 2 (S2 2024) and addressing Phase 1 challenges.

### KEYWORDS

Leadership, sense of belonging, professional identity, engagement, communication.

## Introduction

The Australian Universities Accord interim report highlighted a focus on the sense of belonging that universities “have an obligation to students to foster belonging”, in a time of national loneliness and disconnection in Australia, with a recent report stating that one in three Australians experiencing loneliness (Lim, 2023), more specifically in the Australian university sector, less than one in two students reporting a positive sense of belonging (Social Research Centre, 2022).

Connection exists between sense of belonging and retention, attrition, persistence and academic performance, as identified in the literature, and theoretical framings on belonging often include place-based, identity-based and interpersonal (Crawford, 2024). Different factors fostering belonging depends on student competencies of belonging, opportunities available to students to belong, student motivations to belong, and student perceptions of belonging (Crawford, 2024).

Coordinated and strategic institutional-wide initiatives focused on helping students transition into university, or improving the first year experience, includes intentional and thoughtful integration into the curriculum of first year courses itself, and not be seen from the student’s perspective as ‘bolted-on, piecemeal and de-contextualised’, ‘appear to be irrelevant to the core business of learning’ (Kift et al., 2010). Drawn from QUT’s decade of experience through strategic and policy maturation and evolution, Kift et al. (2010) identified the need for efforts to be transcendent across academic and professional siloes, inviting ownership and fostering right conditions, not only a ‘top-down’ (policy setting) direction, but supporting and encouraging bottom-up innovations, (ie grassroots attempts at the coalface).

Transition into university strategies often used peer mentoring (Gershenfeld, 2014), as exemplified by many Australian institutions, like Flinders University, Adelaide (Egege and Kutieleh, 2015), that recognised its benefits and adopted it in 2012 as a key institutional-wide approach to transition and retention. In Egege and Kutieleh’s review (2015) of the diversity of peer mentoring methods employed in this space, the role of the ‘more experienced fellow student’ mentor is observed as the ‘standard feature of a best practice model for transition’, noteworthy benefits included helping first year students gain a sense of belonging, develop skills in communication and organisation.

The peer mentoring strategy is used for the Faculty of Engineering at the University of Sydney. A peer mentoring program is already in place for supporting the transitioning process, the gap is potentially in a peer mentoring model within the Engineering curriculum that could have an academic and disciplinary focus, woven meaningfully into the course and not ‘bolted-on’ or seen as irrelevant to student learning (Kift et al., 2010). In terms of opportunities for students to coalesce around common engineering disciplines, the University has a strong tradition of supporting student clubs and societies, which are extracurricular opportunities for like-minded and interested students to engage in a common project or competition exists, to name a few, Sydney Motorsport, Rocketry Team. In these instances, informal and formal peer mentoring opportunities exist in collaborative project work, and these relationships are formed organically on a voluntary basis or for practical purposes to pass down institutional knowledge between existing and new members.

Supported by the 2023 Engineering Education Innovation Grant, this paper outlines Phase 1 outcomes of a pilot peer mentoring program within the Biomedical Engineering (BME) curriculum. This mandatory mentoring, distinct from extracurricular activities, is integrated into core BME courses for students in first and third year levels. It paired mentors and mentees based on similar disciplinary interests and career goals, incorporating project work elements similar to student clubs, with their participation directly connected to summative course assessments.

The addition of this type of peer mentoring arrangement within the curriculum is a type of ‘vertical integrated mentoring’, and in combination with the existing voluntary and extracurricular opportunities for students to engage in, such as aforementioned Faculty-wide peer mentoring program and in student societies, constitutes a more wholistic and ‘triangulated mentoring’ approach recommended by Kaul and colleagues (2019) in the STEM context and attempting to add to the ecosystem of student-centric support within a transition pedagogy (Kift et al, 2010).

The pilot program attempts to make use of the two identified factors in fostering belonging in building competencies and providing opportunities (Crawford, 2024) within the academic curriculum.

## **Program goals and hypothesis**

The function of a peer mentor varies depending on a program's specific aims. From considering previous reviews by others on peer mentoring programs, Crisp and Cruz in 2009 and Jacobi in 1991, with Gershenfeld's own review of twenty studies published from 2008 to 2012, peer mentors commonly perform four functions: to provide academic support, psychosocial or emotional support, serving as a role model, and goal setting and helping with career paths (Gershenfeld, 2014). It has been shown that the students' emergent professional and work-related identities throughout their academic journeys have a bearing on their employability and career aspirations (Tomlinson and Jackson, 2019), which in turn affects students' sense of belonging to the profession. Hence, the proposed peer mentoring pilot program aims to kickstart the shaping of a more realistic perception of professional engineering identities in first year students in collaboration with the third year student mentors through collaborative activities.

For the third year cohort enrolled in this project-based learning course required students to work in project teams alongside clinicians, who are project sponsors of real-world clinical challenges. Such deliberate exposure provided opportunities for continuing professional identity formation journeys. Through this program these same third year mentors are empowered to share insights into their own project work through collaborative activities which in turn assists first year students to gain insights into the BME industry and act as a teaser for their future third year course.

The goal of the program's collaborative activities is 1) To provide first year students with a deeper insight into the biomedical engineering program 2) To build leadership opportunities and other soft skills for third year mentors as they lead junior students through focused tasks.

The project hypothesises that these goals can further lead to the development of student engagement, sense of belonging, professional identity and other necessary soft skills relevant to professional engineering attributes for both cohorts.

## **Methodology**

### **Program Overview**

The peer mentoring pilot program is strategically designed to connect two core unit of study (UoS) in the biomedical engineering curriculum comprising of students from the first year (size 201) and third year cohort (size 75). The framework for the activities in this program is oriented towards advancing the insights on biomedical engineering, foster professional identity and incorporate leadership opportunities. The specific activities are methodically designed to not only bring academic value but also other important aspects of professional identity such as advancing communication skills, teamwork, team management, time management and more importantly foster sense of belonging.

The first year UoS content consists of the fundamental engineering concepts and the real world need for biomedical engineering. Similarly, the third year UoS introduces students to the design process of optimal solutions to tackle real-world clinical challenges, creates opportunities for industry engagement, leadership and professional identity development.

This pilot program was implemented in Semester 2, 2023. The program paired third year students with first year students in a 1:3 ratio, facilitating peer-mentoring and collaborative learning activities. The program includes a series of meetings between first year students and third year mentor whereby the assigned mentor assumes various industry related roles and share their project experiences and industry insights with first year student group.

Both cohorts collaborated on design project topics assigned to the third year students through the meetings. Each cohort was allocated their respective assessment tasks. First year students were required to create a group presentation based on the background and fundamental aspects of

their third year mentor’s project. Third year mentors were required to submit a reflection on their professional development throughout the program as an assessment task, including experience working with the first year students as a leader, challenges faced and overcome, and fostering reciprocal learning. Dedicated tutors were allocated to monitor each groups’ progress, accuracy of information dissemination, and supporting mentors in overcoming challenges when required.

### Data collection process

A structured method to gather and analyse both quantitative and qualitative data from participants was adopted following ethics approval from the University of Sydney. Data was gathered using anonymous surveys voluntarily completed after the semester ended and grades were finalised, to prevent any coercion. These surveys, which included Likert-scale and open-ended questions, aimed to capture students’ experiences and perceptions of the program. Questions varied between cohorts, focusing on areas like student engagement, support, sense of belonging, and relevance to their studies. Specific goals such as leadership qualities in third year students and insights into the biomedical engineering program for first year students were also assessed. Survey responses underwent thematic analysis to identify key themes and patterns.

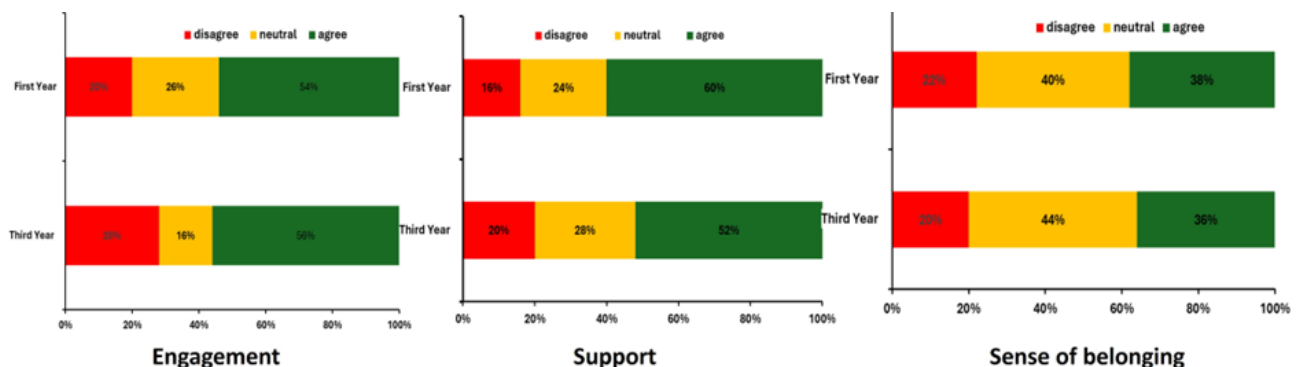
## Results

### Overall indicators for ‘health checks’

Out of 201 students in the first year cohort, 50 students (25%) participated in the survey. Similarly, 25 of 75 students (33%) in the third year cohort participated in the survey and the demographic distribution of gender was collected for both cohorts (first year/third year: male – 26 %/ 40%; female – 64%/48%; Non-binary – 2%/0%; Prefer not to say – 8%/12%) The survey for both cohorts was designed to evaluate three key indicators: engagement, support and the sense of belonging. The questions that captured these indicators are summarised in Table1.

**Table 1: Three key indicators from survey and the questions targeting them in the survey**

Indicator	First year cohort	Third year cohort
Engagement	“I found it beneficial to engage with my 3 <sup>rd</sup> year leader throughout this program.”	“I found it beneficial to engage with my 1 <sup>st</sup> year group throughout this program.”
Support	“I felt supported by the teaching staff facilitating this program.”	
Sense of Belonging	“I had an increased sense of belonging as a result of this program.”	

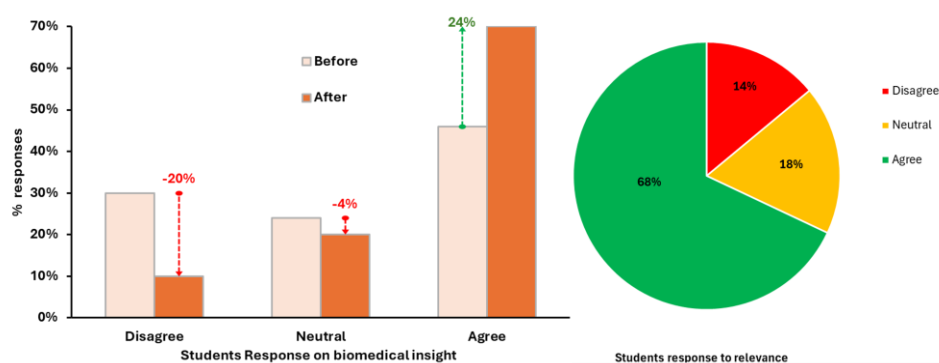


**Figure 1: The percentage response from first year and third year students on their engagement, support and sense of belonging through this program**

Figure 1 shows that over 50% of the participating students in the survey from both cohorts found it beneficial to engage between the two groups in the program. In addition, more than 50% of the participating students indicated that they felt supported by the staff in this program, suggesting that the resources provided, and the approach taken were beneficial. However, the results for sense of belonging were less conclusive, with approximately 30% of participating students agreeing to an improved sense of belonging and approximately 40% with a neutral stance.

## First year perspectives

**Insights gained before and after the program:** In the post program survey the first year students were asked to self-evaluate the strengths of their insights into biomedical engineering before and after the program (Fig 2a) based on the questions as shown below. “I had a strong insight into the biomedical engineering field BEFORE this program.” “I have a strong insight into biomedical engineering AFTER completing this program.



**Figure 2: Percentage response from the first years on improvement in biomedical insight (left) and their perception on the relevance (right) of this program on their unit of study**

Comparing the results, 70% of the students agreed that the program did have an influence on the insights gained. 24% of the agreed students indicate that the program did assist them in advancing their knowledge in the field of biomedical engineering.

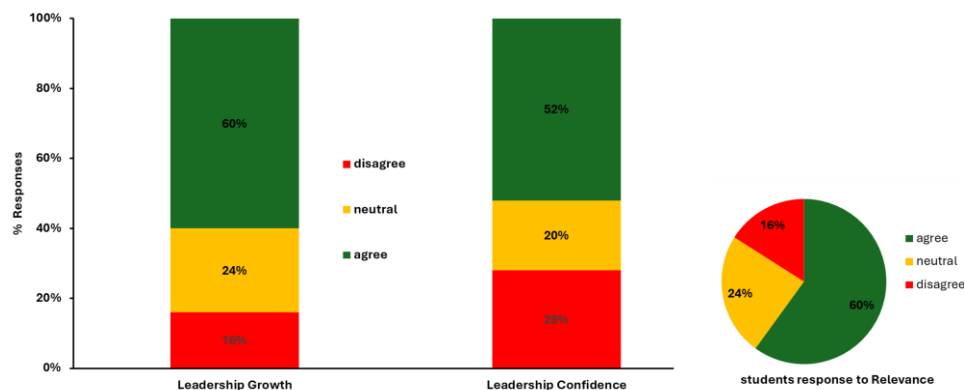
**Program relevance:** The first year students were also asked on their ability to relate course content to the program through the question: “I was able to relate the fundamental aspects covered in the 1<sup>st</sup> year unit to this program.” 68% of participating students were able to relate the course content to the program and 18% remained neutral and 14% were not able to (Figure 2b).

**Connection between relevance and insight gained:** Out of this 68% of students, it was interesting to note that 88% of them agreed that they had stronger biomedical insight after completing the program. Among the 18% of students who remained neutral, 33% felt they had gained insight. Even among the 14% who disagreed with the program’s relevance to the course, 29% of this group still felt they had gained insight. This suggests that the course content is primarily aligned with the program objectives to assist the first year students in gaining insights into the biomedical engineering degree and future opportunities in the field.

## Third year perspectives

**Understanding of leadership:** The third year students were asked to self-evaluate their growth and confidence in leadership skills through the following questions: “I believe I have grown in my understanding of leadership through this program.” - Leadership growth indicator. “I have a strong understanding of leadership after completing this leadership program.” - Leadership confidence

indicator. Self-reporting of a strong understanding can be considered as an indicator of confidence in their leadership abilities.



**Figure 3: Percentage response from the third year students on improvement in leadership skills (left) as well as their perception on the relevance (right) of this program on their unit of study**

60% of third year students agreed that they had grown in their understanding and 52% reported a stronger understanding in leadership skills as a result of the program (Figure 3), indicating that the program had a large degree of success in facilitating an opportunity to develop this important professional skill.

**Connection between growth and confidence in leadership skills:** 80% of those who had indicated that the program helped their growth, reported that they have a strong understanding of leadership. Though some reported that the program did not offer an opportunity for growth, 50% reported they had strong understanding of leadership after the program. 24% of neutral students, 50% reported strong understanding after the program.

**Program relevance:** Furthermore, in a similar manner to the first year students, the third year students were asked to self-reflect on the relevance of the course content to the collaborative program through the question; “The concepts taught and practised through the design projects covered in the 3<sup>rd</sup> year course was relevant to the leadership role I played in the program.”

The students not only appreciated the program for developing leadership skills, but they also found this program to be relevant to the design projects they worked on with clinicians as part of their core content for the unit. 60% of the students indicated that the program was relevant to their UoS whereas 24% of them remained neutral and the remaining cohort disagreed.

### Skill set development

The survey captured the overall skillset developed by both student cohorts in key collaboration indicators, including communication, time management, teamwork, and team management. Students responded to, "As a result of completing this program, which of the following areas do you feel more confident in?" Results are summarized in Table 2.

Analysing the student data set suggests that 88% of third year students have indicated that they have confidence in one or more skill areas. Out of which 64% of them agreed that their communication skill was improved while 56% indicate that the program provided an opportunity to acquire the skills related to team management. The results in table 2 suggest that 74% of the surveyed first year students felt more confident in one or more skill areas as a result of the program. On the other 60% of the first year students indicated that their insight into biomedical

engineering was improved. This result showed that 74% of the surveyed stated that they have felt more confident in one or more skill areas as a result of the program.

**Table 2: % students' response from both the cohorts on their improvement in related skills**

Skills	% student response 1 <sup>st</sup> yr	% student response 3 <sup>rd</sup> yr
Communication	58%	64%
Time Management	44%	32%
Teamwork	60%	-
Knowledge of biomedical engineering	60%	-
Team management	-	56%
No more confident in any area	26%	12%

Also, these results indicated that the students were able to not only get the relevant insight into biomedical engineering or the leadership skills but also had the opportunity to enhance their key skill sets required for their professional growth.

## Discussion

Overall, when taken together, the results from the Phase 1 pilot study were encouraging. The findings of the pilot program are discussed in terms of meeting the stated initial goals and student experience of the program.

Program goal to help shape professional identities in both cohorts has been met. For the first year cohort, this was supported by 24% increase of students in agreement of the statement that they had gained insight after the program, while 68% of those surveyed saw direct relevance of the program to their course (Figure 2). Table 2 also showed 60% of those surveyed improved on their 'knowledge of biomedical engineering'. The connection between gaining insight and perceived relevance from meeting with a third year mentor is further supported by comments in the survey:

*"It was interesting to learn about what we will do in the future of our degree. I enjoyed the mentoring aspect..."*

*"I think the idea of forming connections and relationships between biomedical year groups is very good though and should be continued".*

This starting of professional identity formation for the first year, assisted through the piquing of interest in their future studies in their degree program and imagining of potential career pathways, significantly mediated through insights shared by the mentor, was critical to the fostering of belonging.

The benefits in creating 'vertical integrated mentoring' (Kaul et al., 2019) opportunities to share their newly found insights was also noted by one third year mentor:

*"I really did like getting to share advice with the first years..."*

Though the role of mentors was mandatory in our program, this comment matched comments made by mentors who volunteer based on altruistic motives, such as, 'to inspire others', 'to assist other students' in other peer mentoring programs (Egege and Kutieleh, 2015).

Mentors also gained from consolidating their own professional identity conceptions when sharing insights from their projects with clinicians. Similarly, discussing their personal academic paths in



small groups upon reaching their current positions can serve as an orientation technique that fosters connection and belonging (Crawford, 2024). As a mentor commented,

*"I feel like it showed me that I have actually learnt things during my degree because I could identify the difference between how I was as a first year student compared to now"*

Mentors were given unique and mandatory opportunities in development of skills. In this arrangement to guide first year students in focused activities, results showed both growth and confidence in leadership development (Figure 3). It was anticipated that for some students, this would not be the only avenue in their own personal development to have led others,

*"...I don't think I gained any leadership skills from it that I haven't already developed in other areas of my life..."*

The specifying of different industry leadership roles in the agenda was intended to be a practice opportunity for penultimate year students within their more specialised disciplinary context, which may not otherwise be available in other non-academic parts of their lives. Additionally, rather than a 'bolted-on' activity, this was integrated into taught content within the course itself, offering a more authentic learning activity that resembled project team work environments in industry. This perception of relevance was supported by those surveyed (Figure 3).

For the first year mentees, teamworking and communication skills were among the top nominated improved skills (Table 2), despite notable challenges within team work contexts, as shown in comments like,

*"...My group had someone who was unreachable no matter what sort of social media or email we found of theirs."*

*"...I was very disappointed with my groups effort..."*

Viewed more positively, the presence of a third year mentor to provide advice in their formative first year academic journey transformed a potentially isolating struggle to an opportunity to build meaningful connection with the mentor. As the third year mentor displayed skills in 'communication, empathy and emotional intelligence' (Crawford, 2024), it not only helped to foster the building of competencies of belonging, but also fulfilled the four intended functions of a mentor - to provide academic support, psychosocial or emotional support, serve as a role model, and assist in goal setting and helping with career paths (Gershenfeld, 2014).

From a program execution standpoint, the three 'health check' indicator items selected (Table 1), acted as an evaluative measure from a student-centred viewpoint that relates to their experiences with their respective mentor or mentee, their perception of support provided from staff and the fostering of belonging as a result of program participation.

In terms of overall student experiences of the mentor-mentee arrangement, comments like below seem to point to a rewarding experience for the mentor, and a supportive experience for the mentee,

*"I think the program was a nice idea and I enjoyed getting to know the first year students."* - Third year mentor

*"Since the mentor mainly supported us in the Major Report task (as their projects were more tailored to the group topic), it would've been more helpful to have contact with them during the later weeks in the semester..."* – First year mentee

For the inconclusive result for 'sense of belonging' in Figure 1, within an academic context which may not manifest independently over the period of just one semester, belonging may indeed develop more gradually, influenced heavily by other factors such as enhanced insight and support received. Belonging is often a cumulative experience that can develop from consistent positive interactions and support within the learning environment (Peacock et al, 2020).

Future program iterations will focus on addressing challenges identified in Phase 1. The specific improvements included shaping perceptions on program relevance to academic work,



coordination of meeting time and logistics, course timeline alignment, and setting up matching expectations between cohorts. A refined Phase 2 is currently underway since mid-2024.

## Conclusion

Phase 1 of the pilot program showed insights into how collaborative programs can enhance both individual and collective educational experiences, aiming to nurture more innovative and empathetic engineering graduates with necessary professional attributes. The findings from this pilot study informed the feasibility and effectiveness for such programs in other schools and disciplinary contexts within the faculty. The study's limitations include a relatively small sample size (25% and 33% participation rates), which may impact the generalisability of the findings. Potential biases, such as the sequence of survey deployment, were mitigated through ethics considerations, including no coercion in participation and full ethics approval.

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