Characterising the learning dispositions of first year engineering students

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Characterising the learning dispositions of first year engineering students

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Introduction

The increased adoption of blended learning designs such as flipped instruction by STEM academics has brought learning benefits for many students; however, it relies heavily on students being able to take much more responsibility for their own learning than in traditional lecture-based subjects (Reidsema et al 2017).

Previous studies (Willey & Gardner 2015, 2014a, 2014b, Gardner et al. 2014, Willey et al. 2014) of students in two different engineering majors at the University of Technology Sydney have shown that students who perform poorly in flipped learning environments typically do not demonstrate the agency and self-efficacy necessary to take responsibility for their own learning and hence have difficulty achieving the cognitive changes expressed as learning outcomes in subjects. Poor self-efficacy, that is a competence belief about one's capability to execute a particular action and achieve a particular goal, has been linked to attrition in previous research:

> Many different factors underpin attrition decisions in any one institution and for any one individual, for whom attrition usually results from the aggregation of diverse factors rather than 'the straw that broke the camel's back'. The only attrition triggers which span most universities and years of study are lack of clear reasons for being at university or academic self-efficacy (Willcoxson et al 2011)[6].

Crick and Goldspink (2014) refer to the link between learning dispositions, agency and identity and how students' thinking about these concepts, such as self-efficacy, frames their future learning trajectories. While university programmes generally address knowledge generation, Crick et al (2015) argue that forming a learning identity is also "pedagogically significant".

The research of Thomas (2013) reports that

> ...students often experience stress, uncertainty and use ineffective learning strategies when they are not supported to understand how to direct their own learning... findings suggest that learners can demonstrate increases to cognitive and metacognitive functioning, as well as self-efficacy through engagement with a program to support self-regulated learning...

However, Thomas (2013) also found that there are "significant challenges to encouraging all students to engage with such a program".

Buckingham Shum and Crick (2012) point out that the development of self-regulation and self-efficacy impacts not just student performance at university but also their performance in the workplace:

> Theoretical and empirical evidence in the learning sciences substantiates the view that deep engagement in learning is a function of a complex combination of learners' identities, dispositions, values, attitudes and skills. When these are fragile, learners struggle to achieve their potential in conventional assessments, and critically, are not prepared for the novelty and complexity of the challenges they will meet in the workplace, and the many other spheres of life which require personal qualities such as resilience, critical thinking and collaboration skills.

As more academics adopt blended learning environments in their subjects, these students are at greater risk of not successfully completing their subjects, with a worst case scenario of multiple failures and hence of subsequently dropping out of their course.

Before self-efficacy, agency and other personal characteristics can be developed students need a language to describe these concepts so that they can think about them and talk about them with each other and with their instructors. Conceptual frameworks are useful for guiding data collection and analysis in a research environment, and just as useful in practice for guiding thinking about the various aspects of a phenomenon and the relationships between these aspects. This paper reports how the use of a learning framework, the Crick Learning for Resilient Agency (CLARA) with first year engineering students in two Australian universities has provided us with information about their learning dispositions and given them a language to think about their learning.

Background

The CLARA framework (Learningemergence, 2015) includes eight elements which have been found to contribute to learning ability. These include:

mindful agency: incorporates managing the processes of learning, managing the feelings associated with challenge, and agency in taking responsibility for learning purposes, processes and procedures. It integrates three distinct strands in the research literature: metacognition, the role of affect in self-regulation, and self-efficacy or agency;

sense making: is about making connections between ideas, memories, knowledge, skills, facts and experience – and making meaning of them in relation to each new context of learning and performance;

creativity: is a function of imagination, intuition, risk- taking and playfulness. Playfulness is a way of exploring ideas and testing alternative pathways for problem-solving. It is also instrumental to seeing problems with a 'different lens' which is important in shifting paradigms and worldviews;

curiosity: is about the desire to investigate, find more out and ask questions. A curious learner does not simply accept what they are told without wanting to know for themselves whether and why it's true;

belonging: is about how much a learner feels part of a 'learning community', a group with a shared commitment to learn, improve and do better, whether at school, at work, at home or in the wider community. This learning community provides guidance, support and encouragement in relation to learning;

collaboration: the skills to learn through relationships with other people. It's about solving problems by talking them through with others, generating new ideas through listening carefully, making suggestions and responding positively to feedback;

hope and optimism: hope is related to initiating and sustaining progress towards a goal and hence it is closely related to optimism and self-efficacy; and

openness to learning: is about being open to multiple ways of approaching learning. This dimension is on a spectrum from 'fragile and dependent' at one end (likely to give up easily and depend on external validation for each step in a problem solution) and 'rigidly persistent' at the other (determined to keep doing things the way they always have and less inclined to listen to others). Either end of the spectrum is sub-optimal for learning.

An online survey tool asks students a series of questions and on completion it provides immediate feedback on an individual's profile against the eight dimensions of the model in

the form of a spider diagram which can be used for reflection and a starting point for changing the habits of mind that shape the way an individual responds to a learning opportunity (see Figure 1).

Implementation

After ethics approval, the CLARA survey was administered to first year engineering students during the Autumn 2017 semester at an urban and a regional university in Australia. Both subjects in which the CLARA survey was implemented were engineering design subjects where students were required to work in small groups to create a project plan, in the case of the regional university, and a 3D printed artefact, in the case of the urban university.

Students at both universities were introduced to the elements of the CLARA profile along with related concepts such as self-efficacy, reflection, metacognition, resilience, agency and horizons for action (Hodkinson and Sparkes 1997). The aim of including this content and related activities in their curriculum was to help them develop a language to think about and talk about their learning, to allow them to assess, monitor and evaluate their current strengths and weaknesses and monitor their progress in development of these personal aptitudes needed for learning. The presentation of the CLARA framework during lecture time was supplemented at both universities by tutorial activities. A tutor training session was run at each university so that tutors could experience the activities that students would be engaged in and ask questions and provide feedback on the tutorial design.

The tutorials were run after students had completed their personal CLARA profile and attended the relevant lecture on the framework. During the tutorial tutors summarized the elements of the framework again then divided students into groups of three or four. Each group was allocated one of nine engineering student personas. The group used the description of the persona to draw a CLARA diagram, identify at least one aspect of the framework that could be improved and then generate actions/strategies that could be taken to improve the identified aspect of learning. The tutorials concluded with each group explaining to the whole tutorial why the CLARA diagram they drew represents the engineering persona and presenting what actions could be taken to develop the identified dimension of the framework.

The engineering student personas are compilations of common characteristics of engineering students. Personas have been used in areas such as health technologies (LeRouge et al 2013) and more generally in product design (Miaskiewicz & Kozar 2011). The aim of using these personas was that students would be able to identify with the narratives of different personas and assess the impact of various characteristics on the developmental trajectory of these personas. This would enable students to discuss and reflect on profiles that are similar to their own, and identify strategies for their own development, without needing to reveal their own profile. Although they are fictional characters personas reflect authentic characteristics of real students. Each persona narrative has been validated with a range of engineering academics and students across the country. Feedback from academics and students was also used to ensure that the group of personas represents major cohorts within engineering programs at various universities. For example, the original group of personas was presented at Charles Sturt University and engineering academics there suggested the addition of a persona with a rural/farm background so 'Andrew' was created. Andrew's description is as follows and provides an example of the types of narrative written for each persona:

> *Andrew grew up on a farm in Western NSW and enjoyed tinkering with tractors, farm machinery, and motorbikes so he decided to study engineering. He worked hard during the HSC and particularly focussed on higher level maths and physics and so found those subjects pretty easy when he hit university. He didn't have to study much in first year and so spent a lot of time with his friends in university housing. He is really social and enjoys living with other people after growing up in an isolated community. However, sometimes his socialising gets in the way of uni and although his strong high school results carried him through the start of first year, as the content becomes increasingly complex he is starting to struggle a bit. Through*

his farming experience, he understands the practical parts of design and making sure things are easy to repair, but he isn't doing as well as he'd like in the project based assignments.

One of his favourite parts of UTS is working with the Motorsports Team. He has really enjoyed getting to know other students who love working on cars. His plan is to go into farm machinery design when he graduates, although he's not that optimistic that he'll be able to find work in Australia and hasn't been able to think about where else he could work instead. He is finding it hard seeing how the skills, knowledge and experience from studying engineering might transfer to a different career path, and remains rigidly interested in farm machinery design.

The complete list of personas and their descriptions is available on the aaee-scholar site (http://aaee-scholar.pbworks.com/w/page/1177054/FrontPage) under workshop materials for the OLT Fellowship 'Identity, Agency and helping STEM students understand learning'. These personas are written for a University of Technology Sydney (UTS) context so UTS-specific details were changed and the descriptions fitted into the urban and regional university environments which are reported in this paper.

Observations were carried out at four tutorials at the urban university to determine how well students were able to use the CLARA framework to describe the learning characteristics of the engineering student persona allocated to their group and generate strategies to strengthen the chosen characteristic.

Both universities set low stakes reflective writing tasks for their students related to their use of the CLARA profile. Analysis of the regional university students' comments is based on their response to the prompt:

What study skills and professional attributes do you believe you could develop further as you progress towards your chosen profession? (hint: The CLARA Framework presented in week 2 is a helpful tool to develop this section)

We also analysed text from students at the urban university responding to the question:

How does the learning profile differ from how you have seen yourself?

Samples were drawn from all submitted text to ensure a mix of overall subject grades, gender, and domestic and international students. Twenty-seven reports were drawn for the regional sample and twenty-four for the urban sample. Individual students were coded according to their overall grade, gender and national/international student status (eg. HDa MI – High Distinction student a, male, international).

Reflections were coded in QSR Nvivo 10 using the CLARA framework as a pre-defined node structure. Instances where students directly discussed elements of the framework or recounted experiences and insights attributable to one or more elements of the framework were coded. Surface level statements referring to the framework without detail or insight (e.g. "my sense making improved on the second survey." - with no further commentary) were not coded.

This paper reports on data drawn from student CLARA profiles, tutorial observations and student reflective writing tasks to investigate whether first year engineering students could use the language of the framework to describe aspects of their own learning and which aspects of the framework resonated most strongly with these students.

Findings and Discussion

At the urban university 499 of 520 students undertook the CLARA survey (response rate of 96%) and at the regional university 350 of 446 students completed it (response rate of 78%). This gave us a total of 849 student CLARA profiles.

Figure 1 shows the averaged results for each element of the CLARA framework at the regional university. Figure 2 shows the averaged results for each element of this framework at the urban university.
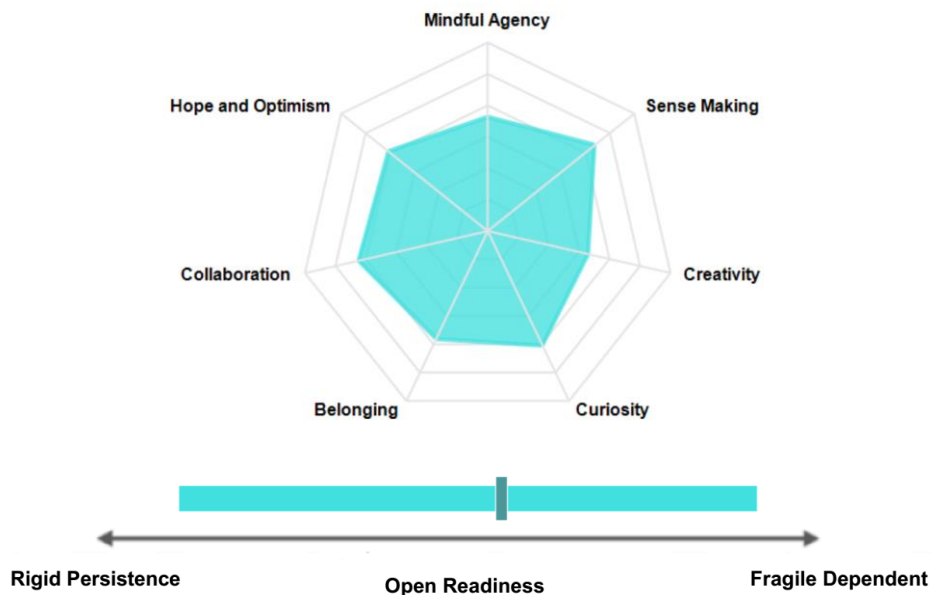
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Figure 1: Averaged CLARA profile results from a regional university, n = 350.
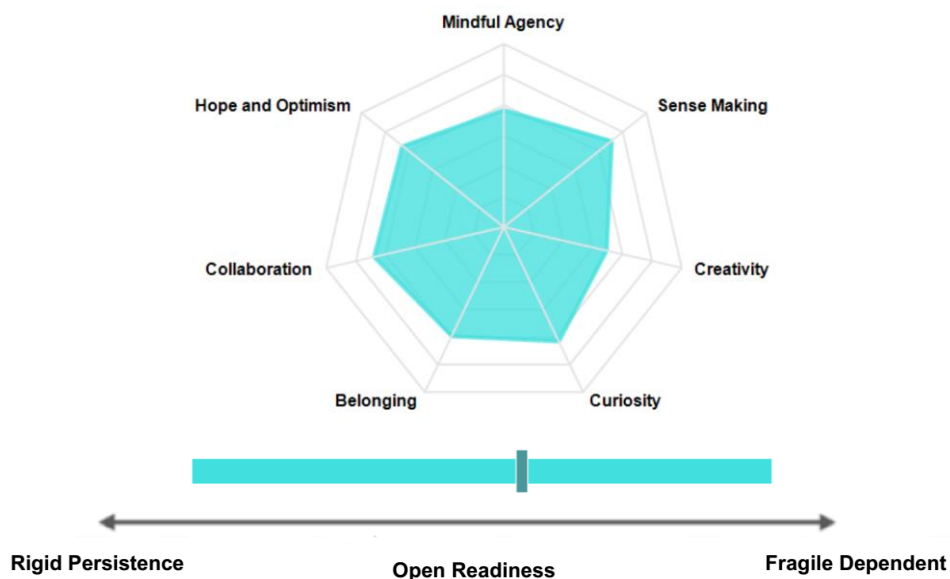

Figure 2: Averaged CLARA profile results from an urban university, n = 499.

The relative shape of the overall profiles for these universities is similar. The early semester results show that these first year engineering students are weakest in creativity and mindful agency, and strongest in sense making and collaboration. Since these profiles were generated from surveys undertaken in week 2 of semester at each university the relative strengths and weaknesses of each cohort is more likely to be a reflection of the NSW secondary school environment than any experience undertaken at their respective universities. These profiles suggest that students in engineering programs would benefit from learning activities designed to encourage creativity. However, to increase retention rates for the first semester of first year we recommend focussing on developing mindful agency and belonging, leveraging of the cohort's relative strength in collaboration to do so with collaborative learning activities

In the observed tutorials student groups generally engaged well although to start with there was some confusion about exactly what the terms in the framework mean e.g. not associating self-efficacy with hope and optimism, not understanding the difference between collaboration and belonging. This was overcome by referring students to the tutorial resource materials which included definitions of each term. They were then able to point to elements of the description of the persona which prompted their rating "We rated her high on belonging because…."; "He shows low creativity here where it says…". Students drew the persona's profiles on the whiteboard so that everyone in the tutorial could see all of them at once and compare profiles.

Student groups typically suggested only one strategy to develop the element of the framework they had identified for development. These strategies were usually not very creative, like 'go to lectures'. This demonstrates the limited horizons of action of many of these first year engineering students and reflects the relatively low creativity result in the aggregated profiles in Figure 1 and 2.

It was interesting that in one tutorial it was suggested that Merindah, Jessika and Regina (all female personas not confident with maths) should think about changing out of the engineering program – this was the only observed tutorial where a group suggested that personas should withdraw from engineering. The option to withdraw from engineering was not suggested for male personas who were similarly not confident with maths, nor for the male persona who was described as having difficulty with writing. The CLARA tutorial exercise prompted this gendered attitude to be articulated and hence potentially interrogated, which may not otherwise occur in typical engineering learning activities.

Reflection Analysis

The distribution of references or comments attributable to each dimension of the CLARA framework are summarised in Figure 3. Most students at both universities mostly commented on mindful agency and collaboration. The regional university students referred to elements of the CLARA framework more frequently than students at the urban university, except for sensemaking (frequency the same at both universities) and creativity (higher frequency at the urban university). The higher frequency of references to the CLARA framework at the regional university may be partially attributed to the fact that the reflective writing task was undertaken at the end of the semester, compared to the urban university where the reflective writing task was undertaken in week 3. The student cohort at the urban university were 44% international students which may also have affected the amount of text they produced. However, analysis of the student texts showed that they were able to use the language of the CLARA framework to describe and reflect on aspects of their own approach to learning, which is what we were investigating. Remaining comments focus on collaboration, mindful agency and belonging.

Collaboration

Comments relating to students' experience of task-focused teamwork and group interaction, and experiences of learning-focused interaction were coded as collaboration. Many comments on collaboration were also related to beliefs, values and intentions for action. These were also coded under other headings such as *Mindful Agency* and *Belonging*.

The regional university subject relied predominantly on team-based learning activities, meaning students' success was highly dependent on the formation of strong working relationships with other students. Unsurprisingly, coding of reflections revealed a strong emphasis on collaboration over other themes. The urban university also incorporated a substantial component of team-based learning, but to a lesser extent than the regional one.

Most comments from regional university students discussed issues of team function in achieving the set assessment task and thoughts on what worked well or what could work well in future. Most reflections included comments attributing learning and academic success to

collaborative partnerships and strong teamwork, with a smaller number highlighting team dysfunction as a feature.
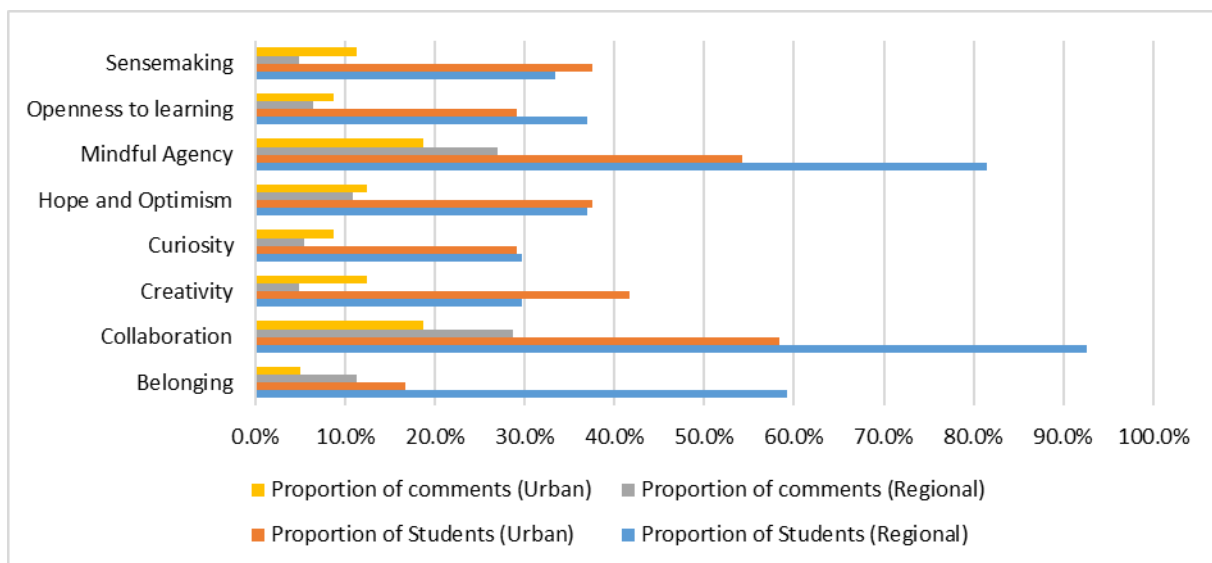

Figure 3: Summary of coding from students' reflective texts

Some students remarked how the team-based approach in the subject had a developmental role, encouraging them to become more collaborative in their approach to learning in contrast to their usual preference for individual study: "As I have always preferred being a solo learner, this improvement is immense, and is one that could still be developed further" (Regional, HDb FD). Of the students who expressed frustration at the poor team function and lack of support from team members, most commented on how their own actions may have contributed to this. Some appeared to see team dysfunction as an outcome of leadership: "What I would do differently is to make sure that each member is adequately doing their work at the start" (Regional, HDd MD). Other students by contrast identified the need to spend more time developing relationships within the team and the benefits of learning to open up to other team members' contributions: "A lot of negatives or areas where I could improve also showed, with time management, organisation, motivation and willingness to listen and adjust to others ideas" (Regional, Cb MD). This contrast highlights different approaches to teamwork – people management vs. collaboration. Suggestions for improvements and personal skill development mostly focused on improving timeliness of individual contributions to team tasks, having more open and honest communication between team members, and addressing problems early.

By contrast, comments on collaboration from urban university students were more focused on learning and approaches to study than any discrete assessment tasks which is in line with the focus presented in their face-to-face sessions. Collaboration was also a less common focus of reflection although still the most common topic overall. Many students valued collaborative approaches to learning. However, comments indicating a preference for individual work or positioning collaboration as a reliance on others were also common:

> *I differ to the results provided as I see myself as one who is able to persist through difficult learning experiences, and although I prefer to work in collaboration with others, I am still able to understand knowledge and concepts on my own (Urban, C6 MD)*

> *I realise I love collaboration and studying with friends, since it can become an encouragement or motivation to me. Studying alone can be boring sometimes, yet for certain studies, I prefer it to be that way because sometimes I rationalise faster and better alone" (Urban, D4 MD)*

This was a feature largely absent from the regional university reflections but may reflect the different nature of the reflection prompts, timing of reflection and design of assessment tasks.

Mindful Agency

Mindful agency also featured strongly. At the regional university this was less often referred to directly, whereas it was usually explicitly mentioned at the urban university. Comments coded as *Mindful Agency* were evidence of students' managing the process of learning – discussing actions taken in response to experiences, discussing feelings associated with learning, taking responsibility for goal-setting, and/or engaging in learning as a process. The prominence of this theme is unsurprising given the nature of the data – a reflective report or ePortfolio entry – but does indicate that students are broadly considering their own responses, feelings, and preferences in learning and the impact of their decisions and actions. Students with Credit, Distinction, and High Distinction grades tended to make numerous and detailed statements with reference to specific events. Students with Pass or Fail grades in the unit overall provided more limited reflections and less evidence of mindful agency.

Reflections coded as *Mindful Agency* were diverse in their focus, but were widely influenced by the language of the CLARA framework:

> *I believe my mindful agency increased due to the amount of planning involved in undertaking such a big project and my need to reflect constantly on previous milestones to improve our marks. (Regional, Cf FD)*

> *I'm studying Design in Architecture/ Civil Engineering. These two interlinked fields requires two different learning approaches. For Architecture, I have learnt to value collaboration, sharing of ideas with fellow classmates. The overly competitive classmates often inhibited the studio learning process. Despite the assessments being predominantly individual, we learnt that the fastest way to improve was to learn from each other (in addition to the tutors) (Urban, D5 MD)*

> *With the amount of stress, I believe that I was not mindful of most of my actions. Most of the semester, I had to do certain things because I had no other option. I never took time to reflect which is why my mindful agency did not increase. (Regional, Dc FI)*

> *However, I didn't realise I lacked in the mindful agency department that much but seeing it in my answers and responses has really opened my mind to what else I could be lacking in... My lack of persistence will probably be my downfall in future and seeing my learning profile has put it in a way so it's clear to me… I knew that I tended to follow a certain way and how I was taught and I knew that I didn't try to create my own methods for solutions because I didn't try to expand on it and think outside the box. (Urban, D6 FD)*

Some students also commented on aspects in their profile which did not change and reflecting on why this may be the case. Other students did not refer to the survey results at all, but still used the language of the CLARA framework. Interestingly, despite direct advice in the assessment criteria, around one third of students in the sample did not refer to the CLARA framework at all. Reflections that did follow the framework tended to address a greater range of learning experience.

Overall, few students' reflections provided evidence of Mindful Agency *during* the semester with the exception of developing collaborative skills and addressing team function. Plans or developmental goals were put forward as future responses to feelings, learning experiences, decisions and choices over the whole semester. To support students in their development of mindfulness and agency, more regular prompts for reflection may be required.

Belonging

Comments coded as *Belonging* referred to individuals' sense of connection to others, to the university, and to the profession. The regional university students' reflections were submitted at the conclusion of a team-based design unit which for most was a first year, first semester unit. The unit itself had been designed in part to help students make connections in their transition to university. This was apparent in students' reflections on their sense of belonging. Students' tended to discuss their interaction with team members and other members of tutorial classes over the course of the semester as either fostering a greater sense of connection, or diminishing it. Of the 16 students in the sample who made reference to their sense of belonging, only four referred to it in a negative sense. All four negative instances were attributed to language issues as a barrier to connecting with others:

> *…because of my poor English skill, I am worry to discuss with group member face to face, that result in I usually distracted due to I cannot understand their meaning sometimes. (Regional, Fc MI)*

> *The group I was in was most unenthusiastic and when [team member] left it was downhill from there. Being grouped with 2 international students was difficult and I found myself explaining many things to them, missing out on important lessons myself. Overall, it was very frustrating to say the least. (Regional, Pd FD)*

While all reported the need to (or for others to) improve language skills, none of these students reported actions taken to overcome this barrier. This suggests that future focus on developing students' agency as a component of learning skill should pay particular attention to strategies for working through language barriers. Belonging was less commonly discussed by the urban university students, only four making reflective commentary on their sense of belonging. All appeared to conflate *Belonging* with *Collaboration* which suggests that understanding of *Belonging* as defined by the framework was less well understood by this cohort. Again, this may be a result of having 44% international students at the urban university.

Conclusions

Findings from this study show that incorporating a learning framework into the curriculum of engineering subjects helped students develop a language to think about and talk about their learning. This allows them to assess, monitor and evaluate their current strengths and weaknesses and monitor their progress in development of the personal aptitudes needed for learning. The aggregated profiles show that these first year engineering students are weakest in creativity and mindful agency, and strongest in sense making and collaboration. These profiles suggest that students in engineering programs would benefit from learning activities designed to encourage creativity. However, to increase retention rates for the first semester of first year we recommend focussing on developing mindful agency and belonging, leveraging of the cohort's relative strength in collaboration to do so with collaborative learning activities. Furthermore, the specific tutorial activities provided an opportunity to identify and discuss otherwise unexamined attitudes to who 'belongs' in engineering.

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