Understanding Participation in a Voluntary Research Program to Increase Engineering Students' Engagement: an Exploratory Case Study

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Abstract

In order to find ways to increase motivation and engagement in civil engineering students, and provide students with a space to develop sense of belonging and engage with their peers through a co-curricular experience, the Icarus program was developed. The purpose of this exploratory study is to understand students' experiences participating in Icarus. The program's goal was to provide students with a different space to develop the desired competencies and skills while simultaneously form their identity as engineers. The research design is an exploratory case study. Data were collected qualitatively and quantitatively. Results showed that the main motivation students had to join the Icarus program was to apply theory from class into real world engineering problems, and to work and engage with peers. In addition, Icarus students demonstrated higher levels of aspirations in their engineering courses, and higher levels of deep learning when compared to other non-Icarus engineering students in the same year. Students' experience with the program was positive and they reported how improved issues related to their academic program, their relationships with mentors, and their perceptions of inclusion.

Keywords: Self-belonging, motivation, co-curricular program, voluntary research.

Introduction

The civil engineering field is expected to solve complex engineering problems with exceptional performance. In consequence, it is expected that engineering students are highly motivated and engaged to succeed in the workforce. However, students' motivation and engagement in engineering programs is difficult to accomplish despite several attempts (Chen, Lattuca, & Hamilton, 2008; Matusovich, Paretti, McNair, & Hixson, 2014; Ohland et al., 2008; Snyder, Barr, Honken, Pittard, & Ralston, 2018; D. Wilson et al., 2014). Similarly, engagement is an important part of learning in engineering (Carini, Kuh, & Klein, 2006; Heller, Beil, Dam, & Haerum, 2010; Kuh, 2009) as students need to feel a sense of belonging within their academic program to effectively develop their identities as engineers. Sense of belonging has been directly linked to successful academic outcomes including persistence, self-efficacy, and perceptions of technical competence (Allendoerfer et al., 2012; Hausmann, Schofield, & Woods, 2007; D. Wilson, Freed, & Shaffer, 2011). In order to feel like they belong, engineering students need to have different systems in place to support and complement their formal education in engineering classrooms. According to Allendoerfe et al. (2012) those systems come together when students have formal incoming cohorts in

classroom and/or labs, and living/learning communities, such as engineering residences where they can interact and develop peer relationships and cohort cohesion, therefore, those spaces are considered an integral part of the college experience. Informal spaces are also important to develop connections with academics and mentors for non-academic reasons in order to develop mentor and role model relationships; and to provide with informal learning opportunities (Kuh, Kinzie, Schuh, & Whitt, 2011).

Results of the National Survey for Student Engagement (NSSE) (2018) identified that including community-based projects (service-learning), participating in a learning community, and working with an academic on a research project are high-impact practices that promote engagement. Research also suggests that a considerable portion of student learning occurs in informal settings, particularly, in out-of-the classroom activities (Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008). Some higher education systems (e.g., United States) are designed to provide students with these opportunities, especially cohort development, student engagement, and mentor relationships with academics; however, in Australia the reality is quite different.

According to the Australian Government of Education and Training, in their Higher Education Funding report (2015) one of the main sources of funding in universities in Australia is through the enrolled students, therefore, there has been a tendency of universities in the last years to increase enrollment numbers which results in very high student to acedmic ratios (Palmer & Hall, 2015). Furthermore, students enrolled in engineering programs in top Universities in Australia have different challenges to develop engagement and sense of belonging. Large class sizes, low student attendance, and a higher education system structured to limit student-academic and peer-to-peer interactions all present challenges for the development of student engagement. In these programs, there is also a culture that pushes for the continuous involvement of students in internships or engineering related work (Kerr, 2010) , therefore a very large fraction of the students have considerable working commitments. Finally, students are mainly commuters living at home, thus attendance to class is conditioned by external variables such as transportation options, work, university schedules, and family commitments. Typical classes have around 300 students, therefore, students find it challenging to meet their peers. In addition, in Australia, digital recording and streaming of lectures has become a standard component of the resources provided to students through learning management sites (McCredden, Baldock, Grainger, & Kestell, 2011), motivating the decrease of student attendance to class, that negatively impact interaction with their peers.

For the particular case of the School of Civil Engineering at The University of Queensland in Australia, there were serious issues regarding students' motivation, perceived by the lack of interaction with academics and class participation. Furthermore, student/staff ratios were very high; hence academics efforts to interact with students were complicated to implement widely. In order to find ways to address these problems, and provide students with a space to develop sense of belonging and engage with their peers through a co-curricular experience, the School of Civil Engineering in 2015 developed the Icarus program. Icarus is a voluntary, project-based, research program where students engage with peers in small projects, directed by academic mentors, with the goal of establishing a small class atmosphere that promotes peer-to-peer interactions, expands learning beyond the classroom, and provides with mentoring and role model relationships. The initial goal of the program was to generate intrinsic motivation in engineering students regarding their civil engineering education.

The purpose of this exploratory study is to present preliminary information about the implementation of Icarus, as an engineering education intervention to promote engagement, self-directed learning, and sense of belonging. The program's goal was to provide students with a different space to develop the competencies and skills desired while simultaneously form their identity as engineers. Icarus is an innovative solution since the School of Civil Engineering had never offered an structured co-curricular voluntary research experience in the past. The purpose of this study was to understand students' initial experiences participating in the Icarus program. More specifically, we address the following questions:

RQ1: Why do students decide to join a voluntary research program?
RQ2: What are students' initial perceptions of belonging and self-directed learning after participating in the Icarus program?
RQ3: How do students describe their experience with the Icarus program?

In order to answer the research questions, we collected data from different sources. We asked the students enrolled in the Icarus program, about their attitudes towards the program and towards engineering in general both quantitatively and qualitatively. In addition, we requested during the application process for students to express the reasons why they wanted to participate.

Our overarching goal was to identify if the program has had an impact on the students' engagement, sense of belonging, and self-directed learning, and if it was worth to maintain this curricular intervention.

Theoretical background

Research by Carini et al. (2006) has demonstrated that student engagement is linked positively to desirable learning outcomes, such as critical thinking and high academic performance, which also positively affect students' learning outcomes (Pascarella & Terenzini, 2005). The Icarus program was thus implemented to make students become engaged with their academic program and their institution.

Floyd-Smith et al. (2010) argued that when developing a sense of belonging that leads to students' engagement, it is very important to also develop a community where students can participate and interact with others. Their model is presented in figure 1. According to Floyd-Smith et al. (2010), when students are engaged (i.e. feel they belong) they will also demonstrate intrinsic motivation, this engagement will lead to short-term and long-term positive academic outcomes.

The Icarus program was structured with this theoretical framework in mind. The expectation was that students participating in Icarus, would positively engage with their engineering program, and with their peers, but not to the expense of their academic coursework. Icarus emphasized the value of the alignment between the research project offered, and the coursework students were enrolled in. We hypothesized that students were going to develop short-term academic outcomes, like improving their critical thinking, problem solving, and research skills; by developing productive relationships with their peers and mentors; and having positive results in the classes in which they are enrolled. Some of the long-term academic outcomes that we expected to develop were having students becoming engaged professional engineers able to successfully finish their engineering program and effectively

adapt to their next step, that being their first professional engineering job, or the decision to continue their education in a higher research degree (i.e., graduate education).

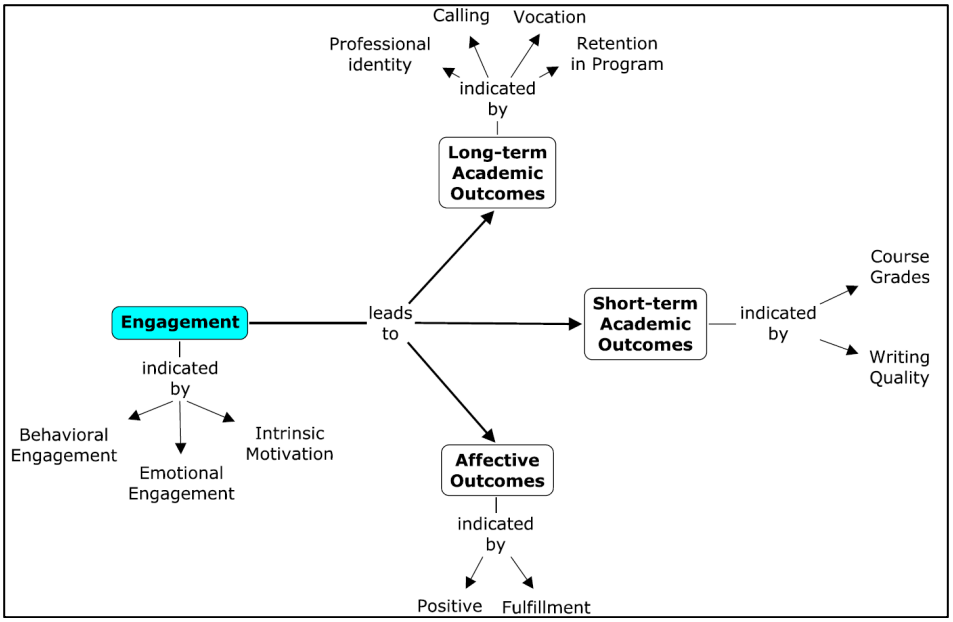

Figure 1. Floyd-Smith et al. (2010) model of outcomes of students' engagement

Currently, Universities in Australia have very low percentages of students selecting a research career track; however, there is a need in the country to motivate more students to complete a higher degree by research (Report for Research Training in Australia, Department of Innovation, Industry, Science, and Research, 2011). The Icarus program had also the goal of providing students with experiences that allowed them to understand that industry internships are only one of many ways of acquiring out of the classroom skills and experiences to develop professionally. Hence, we developed the program to let the students guide the way they worked and have complete control over their involvement and participation on it. An important aspect is that the focus was completely removed from outcomes when it came to the students. We encouraged academics to put projects that resulted in positive research outcomes for them (thus projects had to be very well thought). In contrast, students were not required to achieve or deliver anything, it was their own initiative. A successful project was not one that delivered outcomes but one that delivered engagement. Although this study is exploratory and we are not measuring any outcome as part of it, we plan to conduct further research in the future to identify and measure the learning and professional outcomes of the Icarus program.

On the impact of extracurricular activities on undergraduate students, there is research supporting the notion that out-of-the classroom learning experiences promote students' engagement with their academic programs among other positive outcomes (D. Wilson et al., 2011; D. Wilson et al., 2014; N. Wilson, 2009). D. Wilson et al. (2014) explain that when student participation in extracurricular activities is voluntary, students have higher levels of "academic conscientiousness" (p.627) which the authors define as a as willingness to raise their academic standards, this includes how they perform in the classroom, understand class materials, but also is related to how they conduct research and help and interact with classmates. We considered that Icarus students that are participating in voluntary research projects would obtain these positive outcomes.

Allendoerfer et al. (2012) explains that providing students with opportunities to belong help them overcome some of the needs they face during their time in college, and provide "the most return of investment for engagement in academic endeavours" (p. 512). The authors suggested that the most important part of providing sense of belonging and engagement are activities that enable students to receive family-like support, such as (Allendoerfer et al., 2012, p.531):

- Formal cohorts of incoming students in classroom and/or labs
- Living/learning communities, such as an engineering residence
- Design teams/lab partners, scaffolded for success with respect to the team relationships as well as the project goals
- Weekly informal gatherings with academics, staff, and students for non-academic reasons (e.g., departmental tea, lunches in the dining halls, etc.)
- Academically-related clubs, with space to meet and 'hang out' to facilitate community

Furthermore, as explained before, according to NSSE (2018), including community-based projects, participating in a learning community, and working with an academic mentor on a research project are high-impact practices that promote engagement. The Icarus program was designed to provide several of these activities. Students members of the program considered themselves as to being in an Icarus "cohort", the program also provided scaffolding for general academic success through building team relationships and project goals while they participated in the voluntary research projects and in cross-project activities that highlighted the social aspect of the program. These social aspects, provided students with informal spaces to interact with academic mentors and peers in non-academic settings (e.g., end of semester BBQs). In addition, the Icarus program had a room available for the students to facilitate community interactions. These factors align with the criteria proposed by Allendoerfe et al. (2012) to provide the family-like environment that students need to become engaged and feel they belong.

In addition to sense of belonging and engagement, another theory that informed the creation of the Icarus program is self-directed learning. Baxter-Magolda (2004) explains that knowledge is socially constructed based on interactions between the "self" and peers. Therefore, learning environments designed to promote mutual construction of knowledge also promote self-authorship and provide students with the opportunity of develop learning skills to adapt knowledge to different situations –a desired skills for engineers. Candy (1991) explains that learning is rarely a phenomenon that occurs in isolation; rather it usually occurs in the context of social grouping. Self-directed learning provides students with the confidence and power to have agency over what they want to learn and how they do it (Candy, 1991). In Figure 2, we present a representation of self-directed learning framework based on the work proposed by Baxter-Magolda (2004) and Candy (1991).

The Icarus program promotes self-directed learning in the students that goes beyond their own learning; students recognized and understood that they were contributing to the wellbeing of the School. The School of Civil Engineering also demonstrated its commitment with the students and the Icarus program by the development of several policies and administrative decisions. From the onset, we engaged the School Industry Advisory Board with the Icarus program and the Icarus students, the students also actively participated in events, and different types of professional and engagement activities.

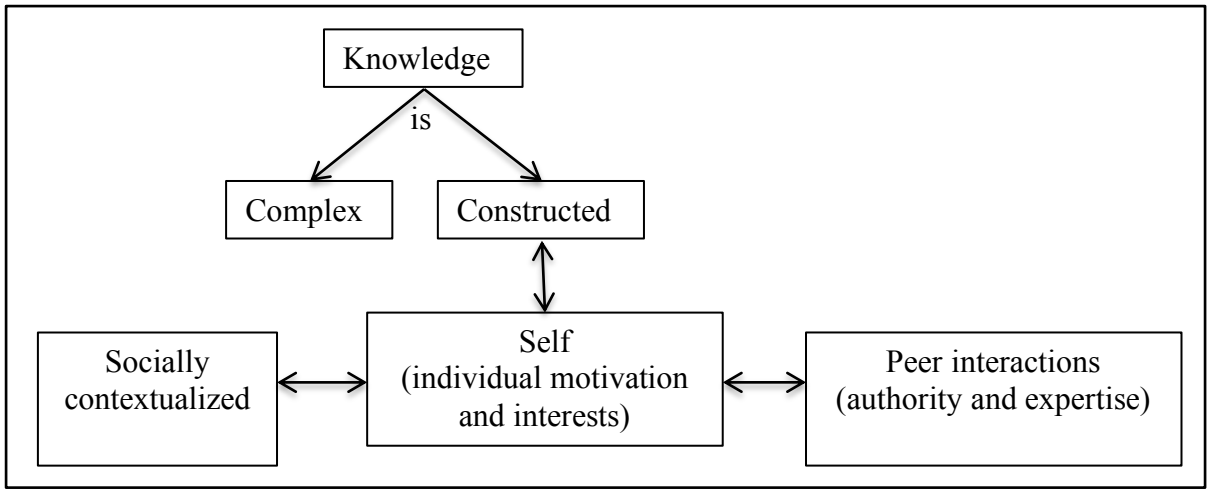

Figure 2. Self-directed learning adapted from Baxter-Magolda (2004) and Candy (1991)

In the following section we provide a full description of the Icarus program, an innovative engineering education initiative to promote sense of belonging, engagement, and self-directed learning in engineering students.

The ICARUS Program

The Icarus Program was developed as a pilot engagement program in the School of Civil Engineering at the University of Queensland (UQ). Students in the program participated voluntarily in research projects lead by mentors who are part of the academic staff in the School. The Icarus Program was developed with three primary goals:

- to boost undergraduate student interest and experience in diverse and interdisciplinary projects;
- to foster close collaboration between academic mentors and small groups of students, and
- to leverage this engagement to elevate student learning pathways, student career outcomes, and UQ's national and international reputation for producing the leaders of tomorrow.

The Icarus program was created on several premises:

1. Research programs proposed for Icarus had to be an integral part of the academic research program. It could not be perceived as another task, rather, it had to lead to a productive activity that had value on its own.
2. The objective of the research program had to be aligned with the second-year core courses learning outcomes in such a way that the research experience contributed to students learning. Ideally a student could choose only to follow the Icarus learning path and still be assessed for the required learning outcomes of the second-year core classes.
3. It had to be voluntary and by application, so we could monitor enrollment.
4. Admission to the program had to be assessed based on the application process and not based on any other indicator (such as GPA), thus motivation was a primary selection criterion.

The program officially started in the first semester of 2015 with four projects across structural, environmental, and transport civil engineering streams. For the initial semester, 60

students were enrolled with the program. Students were in the second year of civil engineering, however, it was the first year in the civil major, since the first-year courses are non-discipline specific engineering classes. Students' committed 2 to 4 hour per week of work and active contribution in the research project, supervised by an academic mentor, however, the project was intentionally non-structured such that students have to decide and direct how to engage and learn from it. During the first semester, students had 24/7 access to a student-run design studio space, and the opportunity to work closely with project mentors in small settings, and collaborate with motivated peers. In addition, mentors tried to make students apply knowledge that they were acquiring in the second-year classes (structures, environmental, and transport). Hence, there was an intentional overlap of learning outcomes. Students, through the research projects, were acquiring the learning desired for the courses.

The program was developed to complement academic's teaching and research effort and students' curricular and extracurricular time. The program allows students and academic to spend more time together on diverse and small-cohort projects with the goal of generating a sense of belonging for the students in the discipline, and minimizing the barriers and power distance between students and academics. In addition, from a research and educational perspective, the program has been identified as a supplement to the civil learning material with civil research and extended non-civil learning material. By the end of the semester 1 2016, just three semesters after its initial pilot, the Icarus program had grown considerably. It had 144 students working on 39 different projects. In addition, from having 6 mentors in the initial semester, Icarus had 24 academics serving as mentors for the students in the following areas: environmental, geotechnical, computational mechanics, hydraulics, fire safety, structures, transport, wind, construction management, entrepreneurship, and architecture. There were also several industry-sponsored projects where students had the chance to not only conduct research and interact with academics but to participate in real-world research solving problems for these companies. In Figure 3 it is possible to perceive part of the growth of the Icarus program over its first 3 semesters.

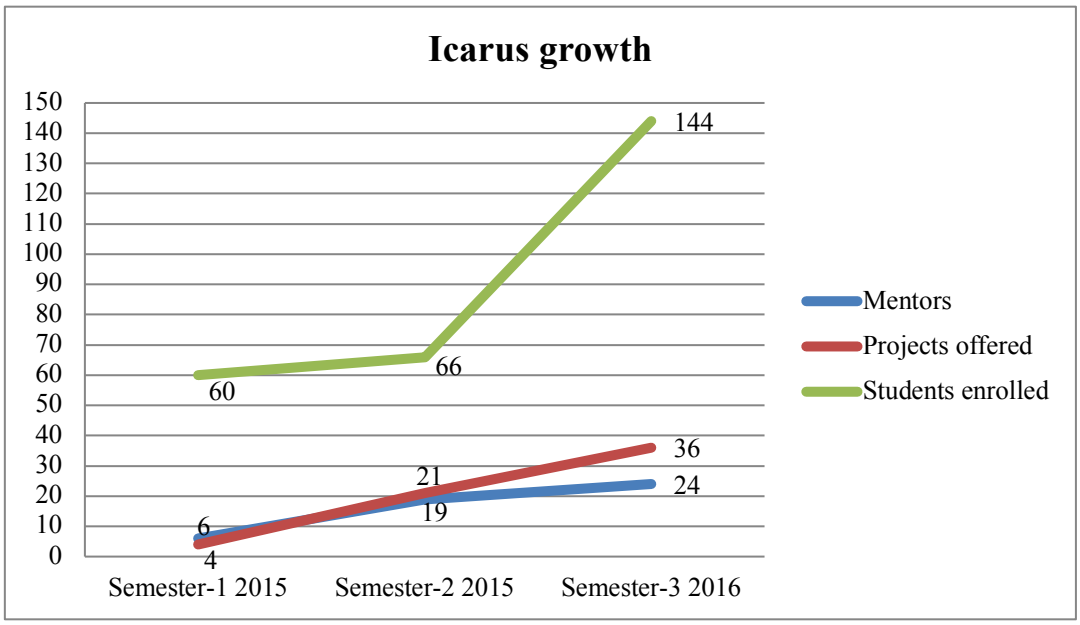

Figure 3. Icarus program growth in 3 semesters

In order to contextualize the scope and the range of Icarus projects, we want to describe in this paper some of the projects and the impact they have had in different areas of academia

and industry. “The Turbidity Challenge” project is a good example from the research perspective. The goal of the project was to analyse and develop a low-cost turbidity monitoring network to address key issues in coastal management. The students were involved in the completion of the largest and most comprehensive survey of Moreton Bay sediments to date; 220 sites were sampled over a 1500 km2 area in a 3-month field campaign with all students participating in both the field work and laboratory analysis. Results from this project were included in the Health Waterways Ecosystem Health Report Card for 2015, which assesses the health of waterways across the entire South East Queensland region. Furthermore, the team was announced a finalist in the Healthy Waterways Awards 2016 People’s Choice Awards. Students who participated in this project have continued the engagement in the project for 3 consecutive semesters.

Some other projects demonstrated an alignment of learning outcomes between project and class perspective. “The Station Simulation” project was proposed to use virtual technologies to simulate a Bus Rapid Transit (BRT) and find operation scenarios that could reduce or remove peak hour congestion. The project allowed the students to use state-of-the art simulation software tools to solve a complex local problem. In a small team, students created and analysed factory, bank, toll booth, airport, and train station models with 2D/3D model animations and learned basic Discrete-Event Simulation (DES) and Agent Based Simulation (ABS) modelling skills. Students re-created the Cultural Centre Busway Station located in Brisbane, Australia as a virtual BRT station simulation model. The students presented their preliminary study results at the 2015 Australian Transport Research Forum (ATRF), under the title of “An agent-based simulation model to evaluate a real-time passenger information system in a Bus Rapid Transit station”. The Station Simulation team won the runner-up for the David Willis Best Poster award.

From an international engagement perspective, the “The TOMMbot” project was a joint research investigation by the School of Civil Engineering at UQ and the Motion Structures Laboratory at Tianjin University in China. The project aimed to build structural “transformers” and determine suitable uses. In brief, it aimed to achieve this with a hybrid origami mechanism that functions as a large, transformable sheet. Students participating in this project were expected to develop creative, user-centred design, and rapid prototyping skills to generate TOMMbot application ideas and build basic prototypes. Consequently, students employed ideation design methods to find applications of the morphing origami technology. They used this to develop a morphing shelter application that was entered into the Road Side Rest Area Design Competition. Their design entry was selected as a Runner Up. Students successfully prototyped a full-scale morphing shelter as well as an experimental-scale deployable shelter. Furthermore, the students visited the Motion Structures Laboratory in Tianjin University in July 2015. They worked in conjunction with Tianjin University graduate students on morphing and rigid origami structures.

Some Icarus projects have also been developed based on industry engagement. For example, one project is trying to improve the CityCat ferry service operations in Brisbane, by creating a demand-based scheduling system that can increase the level of ferry transport serviceability. This project was developed in conjunction with the Brisbane City Council. Also, there have been several projects developed with Brisbane airport to improve the understanding of the experience of both the general public and specific groups (particularly families and passengers with limited mobility and disabilities). In particular, the projects focus on supporting the continuous improvement of BAC’s central security and passenger

processing and the Disability Access Facilitation Plan (DAFP) to a 'world's best' standard of customer experience.

In addition to the research projects, Icarus offered students and mentors several social activities throughout the semester. Despite having two academics supporting everything in the program, students decided to create a student management committee that is in charge of the organization, administration, and control of the program. Students in the management committee developed a sense of autonomy and commitment to Icarus, with the goal of growing it sustainably over time with the support of the School of Civil Engineering.

The Chair of the student management committee became a full member of the Industry Advisory Board by petition of the external members of the Board. Furthermore, from a community building perspective, it is important to highlight that most students enrolled in the program to try it for one semester and the majority has decided not to leave, some of them expressed that would continue engaging with Icarus projects until the time they graduate, because of the value they find in the program for their identity development as engineers.

Methods

In order to address the research questions, we used a case study approach to examine students' experiences after participating in the Icarus program. A case study approach allowed us to use different sources of data to explore these experiences in depth bounded to the participation in the program (Yin, 2018). A case study approach is also appropriate because we were interested in obtaining preliminary information about the program, hence, we were focusing on the process (students' experiences) rather than the outcomes (e.g., learning gains). Furthermore, students experiences are uniquely tied to voluntary participation in the program, supporting that the phenomenon under study cannot be separated from the bounded context (Yin, 2018). Our case is the Icarus Program, extensively described in the previous section, where we collected preliminary data quantitatively and qualitatively.

Quantitative data

For research question one, we analysed the application form that students submitted to participate in Icarus. Responses from the form were quantified to identify the reasons students had to participate. For research question two, we developed a survey that was answered by the students in a mandatory course. The sample included students that participated in the projects at the end of the semester 1, 2015 (i.e., the end of the first semester of Icarus as a program), and students that did not participate in the Icarus program. The study secured ethical clearance by the Human Research Ethics Office at UQ approved under the number 2016001501.

The sample of Icarus students consisted of 49 engineering students enrolled in their second year, most of them from civil engineering, with some students participating form mechanical and chemical engineering. The sample represented 76.5% of the initial cohort of the Icarus program. All the participants were part of an Icarus project. In the sample, 52% were male and 48% were female, 78% were domestic students and 12% were international. Information about participants' GPA is shown in figure 4, it is clear that students participating in the Icarus program were not the top-performing students in terms of GPA. In addition to the 49 Icarus students, 67 engineering students from the same cohort (i.e., second year) took the

survey in order to be able to compare some of the Icarus students' responses in relation to the other engineering students' responses.

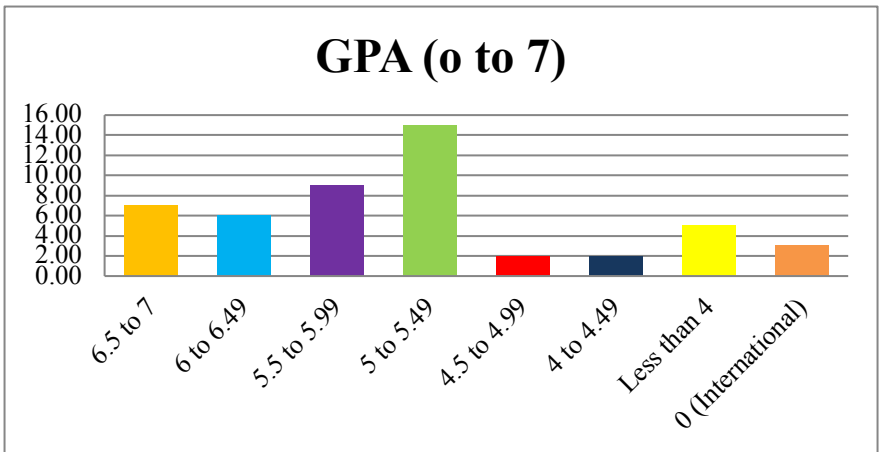

Figure 4. GPA of students' sample

The survey was administered in a hard copy version during class, and participating students signed a consent form. The survey was developed with the objective of better understand students' initial attitudes toward the pilot Icarus program in terms of sense of belonging, engagement and self-directed learning. In order to do that it measured the following constructs:

1. *Identification* with the engineering cohort, which is the degree to which students identify as an engineering student, and feel a sense of connection with other engineering students. E.g., "being an engineering student is an important part of who I am"

2. *Deep learning*, characterised by critical analysis of new ideas and an attempt to extract underlying principles and ideas and translate these into a greater understanding of a topic. E.g., "I find the most engineering topics interesting and often spend extra time trying to obtain more information about them"

3. *Surface learning*, characterised by an emphasis on rote learning and memorisation of details without active engagement with study material. E.g., "I generally restrict my engineering studies to what is specifically set as I think it is unnecessary to do anything extra"

4. *Expectations and aspirations*, assessing how well students think they will perform and hope to perform in their classes. For example: "Compared to other students, how well do you think you will do in engineering this year?" and "Compared to other students, how well do you hope you will do in engineering this year?"

5. *Relevance and intention*, assessing intentions to complete an engineering degree and perceived utility of engineering degree content for future career prospects. For example: "I intend to finish my engineering degree"; "How useful is learning engineering for what you want to do after you graduate?"; and "How useful is learning engineering for your daily life?"

In addition to the preliminary data from the survey, we also collected qualitative data by doing semi-structured interviews with students that participated in the program.

Qualitative data

To answer our third research question, focused on understanding overall students' experiences with the program, qualitative methods that provide rich descriptions were appropriate (Creswell, 2013; Leedy & Ormrod, 2005). We used thematic analysis methods (Braun & Clarke, 2006; Robson & McCartan, 2016) to investigate students' experiences after participating for one semester in the Icarus program. Data were collected from semi-structured interviews with 12 undergraduate civil engineering students at the University of Queensland in Australia during 2016. Specifically, interviews were conducted with participating students at the end the semester when they participated in the Icarus program for the first time.

Thematic Analysis Methodology

Thematic analysis is defined by Braun and Clarke (2006) as a method of identifying, analysing, and reporting patterns within qualitative data. According to Robson and McCartan (2016) thematic analysis is a generic qualitative method not linked to any particular theoretical perspective. Since we were interested in identifying, analysing, and reporting the patterns of the interview data, the use of thematic analysis was appropriate for this data. Robson and McCartan (2016) suggest that thematic analysis can be used to better understand "experiences, meanings and the reality of participants" (p. 474). In addition, thematic analysis seeks to describe patterns across qualitative data to understand a phenomenon in question (Braun & Clarke, 2006). The phenomenon being studied in students experiences after participating in the Icarus Program.

Participants

The participants of this study were civil engineering undergraduate students that participated in the Icarus program voluntarily. Participants were 12 students, 4 were female, and 8 were male. All the participants were in their second year of civil engineering. Participants were invited to participate voluntarily in the interview, and there was no compensation for participation. It is important to note that the Icarus program had 51% of female enrolment, and 43% of international students' enrolment which is non-typical of the civil engineering population.

Data collection and analysis

Data were collected using semi-structured interviews. The interview protocol was informed by theoretical frameworks of self-directed learning (Baxter-Magolda, 2004), sense of belonging Allendoerfe et al. (2012) and co-curricular support best practices (Lee & Matusovich, 2016). The first version of the interview protocol was piloted with 4 graduate students. The interviews were conducted in a private location. A consent form was developed and read to the students before the interview started. After discussing the consent form the students signed it and the interviewer started audio recording the interview. Interviews lasted between 45 minutes up to 55. There were no interviews that went further than 55 minutes.

Data were analysed using a thematic analysis approach. The analysis process was inductive and the themes and codes emerged from the interaction of the researchers with the data (Robson & McCartan, 2016).

Table 1. *Codebook*

Theme	Sub-theme/Code	Definition
Academic Program	Icarus vs. Lecture	Comparison of how the Icarus program learning outcomes and settings compare to the learning outcomes and settings of lectures
	Teamwork	Perceptions of how the program developed ability to collaborate with others that were not acquired in traditional learning settings
	Motivation to join the program	Students' reasons for joining the Icarus program as a complement of their formal civil engineering education
	Becoming an engineer	Students' perceptions on how participating in the Icarus program they were developing their identity as a practicing engineer
Mentorship Relationships	Changing perceptions of academics	Students' initial negative perceptions about academics changed after participating in the Icarus program
	Impact on lecture participation	Students' interest to attend and participate in Lecture after socializing with their professors in the Icarus projects
	Understanding of academia as a career path	Deep understanding of the meaning of taking the academic path as civil engineer which involves research, teaching, service, and student mentorship
Inclusion and diversity	Peer relationships	Students' relationship with other civil engineering students beyond course traditional interactions
	Cohort feeling	Participation an academic unit that identify itself as the Icarus Cohort that shares similar interests and motivations
	Sense of belonging	Increased feelings of identification and belonging to the University of Queensland, and the School of Civil Engineering after participating in the Icarus program
	Reinforcing being good enough for engineering	Students overcoming fears of not being good enough for an engineering career, and feeling capable to do engineering work

A codebook was developed based on the comparison of the codes and the themes. Table 1 shows information about the first level of codes and the themes that emerged from the data. The themes represent the main topics that were designed when developing the interview protocol. During the analysis, there were more levels of sub-codes and every time a new code or theme emerged, the authors went back to the transcripts already coded to make sure new codes and themes were not left outside the initial analysis. During this inductive process, there were several memos that were taken into consideration when developing and establishing the relationships networks between themes, and the connection between the data, the research question, and the theoretical considerations.

During the data collection we took several notes and memos, and went back to the original transcripts several times to revise the information. Following thematic analysis procedures (Braun & Clarke, 2006; Robson & McCartan, 2016), we transcribed most of the recordings increase familiarization with the data. Pseudonyms were used to ensure anonymity of the participants, and some information like name of courses, professors, and Icarus projects were changed. Notes taken during the interview were included when analysing the data to facilitate the development of memos.

The MaxQDA software was used to code the interview line by line. Robson and McCartan (2016) recommend the use of a qualitative data analysis software to have a single organized data storage location, to have quick and easy access to the coding system, to make sure there is a consistent coding scheme, and to be able to analyse differences, similarities and relationships between the codes developed. Codes were developed and two different researchers compared initial codes and agreed on the coding system. Once all parts of the data were coded, codes were grouped based on their similarities into themes. To maintain trustworthiness two researchers coded independently all the interviews and grouped the codes into the themes developed. Using MaxQDA it was possible to establish inter-rater reliability by having a visual representation of the codes.

Finally, data were integrated and interpreted (Robson & McCartan, 2016) so that patterns were identified in the data to describe the phenomenon. The connection between themes can be seen in Figure 5 where a visual representation of the story that emerged from the data analysis is presented. The results section includes detailed information about the interpretation of the findings.

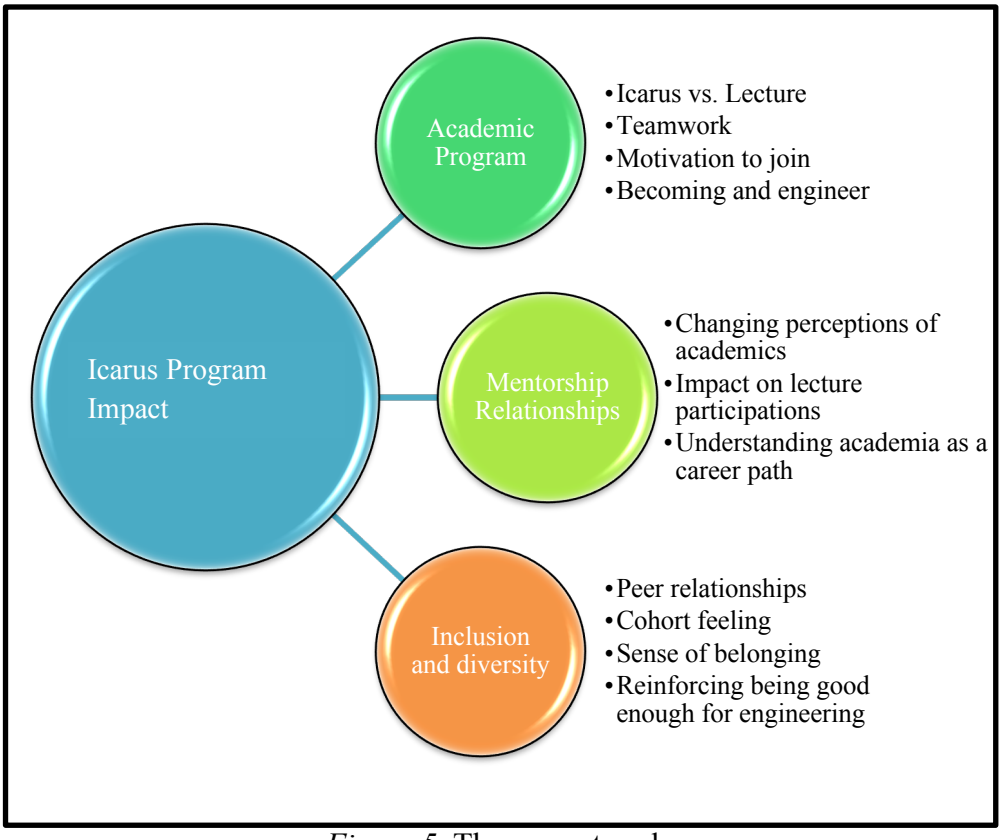

Figure 5. Themes network.

Results

Quantitative results

The first research question aimed to understand what was the motivation for a student to join and invest time of their own in a voluntary research project. Table 2 summarizes the responses from the 49 students. In the discussion section, we elaborate more on these results.

Table 2. *Students' motivation to join the Icarus program*

Why would you like to join the Icarus program?	**%**
Apply theory from class into engineering real world issues	27.88%
Work and engage with peers	15.93%
Expand interest on specific technical topic	14.60%
Better understand the engineering profession	8.41%
Get to know academic mentors	6.64%
Develop teamwork and interpersonal skills	6.19%
Enhance engineering skills	4.87%
Have hands-on experience	3.10%
Engage in a research / Understand research practices	2.65%
Develop problem-solving skills	2.21%
Participate in extracurricular activities	2.21%
Knowledge beyond the grades	1.77%
Engage in innovative engineering research	1.33%
Enhance resume	1.33%
Have fun	0.88%

It is important to mention that our original intention of alignment with core courses was challenged by these results. We thought this would be an element of value that will encourage the students to participate but it did not register in the survey. Other things seemed to matter more to them. However, many of the academic mentors still saw value in connecting the projects being offered to the relevant topics students are learning in their classes, which also matches the first option of the students of applying what they are learning the classroom in a real situation. The second research question was about students' initial attitudes of self-belonging and self-directed learning after participating in the Icarus program.

Based on our survey responses, in terms of sense of belonging we are reporting:

- how they identify (figure 6)
- expectations and aspirations (figure 7)
- relevance and intention (figure 8)
- in terms of self-directed learning: deep learning and surface learning (figure 9).

In addition to Icarus students' responses, we provide second year engineering students' responses not with the intention of comparing statistically significant differences, but rather as a reference on what the initial perceptions of the Icarus students are.

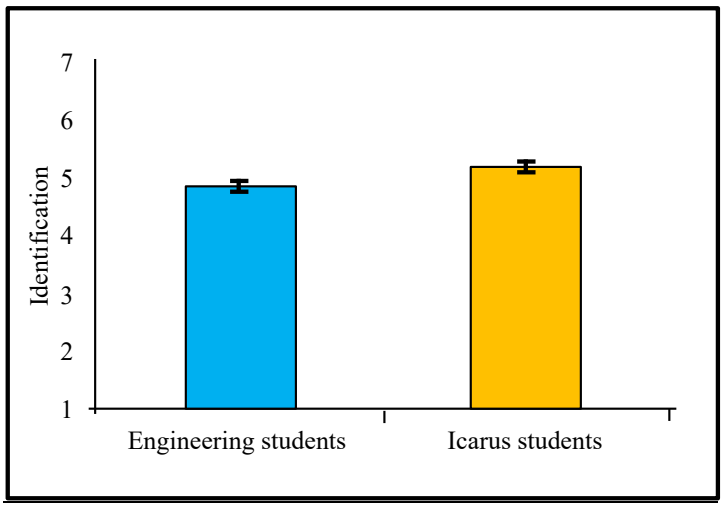

Figure 6. Students' responses for identification

Regarding expectations and aspirations (Figure 7) it is possible to see that Icarus students wish (aspire) to do better in their classes compared to other engineering students, however, when asked about their expectations they had lower levels of expectation of doing well in their classes than engineering students.

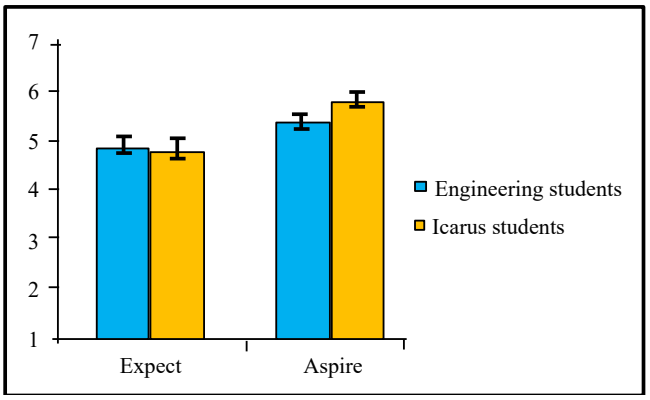

Figure 7. Students' responses on expectations and aspirations

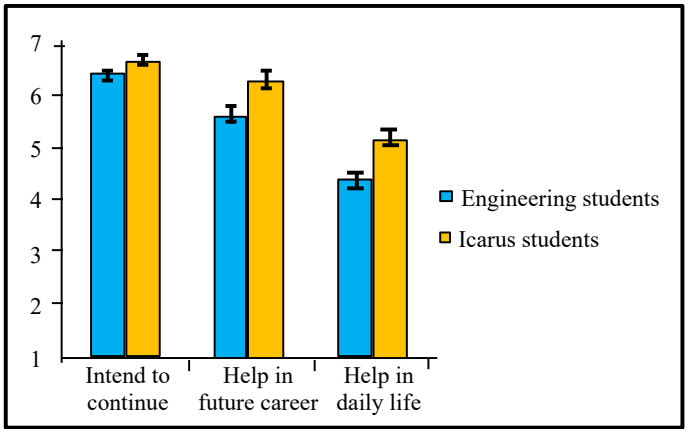

Figure 8. Students' responses for relevance and intention

Regarding self-directed learning, Icarus students reported more deep learning that other engineering students, at the same time engineering students reported more surface learning than Icarus students. Although this data does not demonstrate causality, and it is not possible

to make any inferences, this provides with an interesting example of things to study further regarding the Icarus program, and the evaluation of its impact and its learning outcomes.

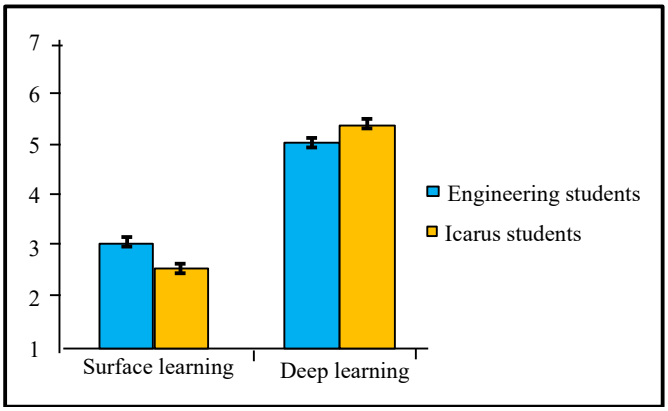

Figure 9. Students' responses on self-directed learning

Qualitative Results

Investigating students' perceptions of their overall experience in the Icarus program helped us understand the relevance of the program regarding engagement and sense of belonging. The following sections describe the main themes identified in our results.

Academic program

Students revealed several aspects of the Icarus program that complemented what they learn in lectures. Initially, students reported that trough the Icarus program, they were able to complement the knowledge that they received in lectures. In addition, students perceived Icarus as a motivator to go to the University, which directly implies higher attendance to Lectures. Two students commented:

> I learned why we learn in the lecture. I mean, I learned why things are being taught to students. If I wouldn't do Icarus I would be in the lecture or listening to the lecture and thinking yes this is going to be in the final exam. Yes, alright I will just study for the final exam. Since I was in Icarus with Mentor 1, I knew why actually people actually build the roundabout and why people would have the roundabout. [I#4Female]

> I actually had a connection with the reality and the lecturer, and it was my - it was a good thing actually - motivating, making that kind of connection - they would actually try to always make us learn, but the Icarus program actually triggered more so that I can connect with reality and I actually knew why they teach this, and I wanted to learn more out of this. [I#12International]

In addition, students commented on how being in Icarus changed their perceptions about teamwork. Initially, they had the perception that teamwork was something they needed to do because it was a program requirement, but they didn't see the benefit of doing it. However, after seeing how working in teams with others to be able to achieve the Icarus projects, they realized the importance of understanding how to collaborate with others, additionally, they changed their negative perception about teamwork, as an international student explained: "I generally when I'm particularly working on an assignment, I like to work by myself because

then I can concentrate but, having a voice input was a new rewarding experience." [I#1]. Furthermore, the international students recognized that Icarus represented a new opportunity to demonstrate to other students that their perception was important to find alternative ways to solve problems. Student # 11 (International) explained: "I think part of the reason the station simulation group did very well was because our demographic was a little bit different than the typical, I mean we had 2 international students and we were encouraged to provide our perceptions."

In addition, students felt that by joining Icarus they had a competitive advantage in comparison to other students. One student explained: "So that's actually why I joined Icarus, hoping that I'd have an advantage compared to other students who didn't. So that I can potentially get into the field that I want which is really difficult specially if you are a woman." [I#6Female]

Finally, students recognized Icarus as being an important part of them to become an engineer, a feeling that they haven't felt so far in their traditional lectures. As Interviewer #5 explained:

> I was actually the person who wants to get that degree - that's it, but as I moved on to this kind of atmosphere, they actually gave me the feelings that I should be here with a reason, and because I was in Icarus I found that reason, too. I actually - I am here to learn things and to be a civil engineer - I knew what kind of attitude and perspective I needed to have. I actually learned that kind of thing from students and mentor. So yeah, it's a lot.

Mentorship relationships

One of the aspects of the Icarus program that have had a positive impact on the students is the improvement of the relationships between students and faculty members. As a consequence, students felt that their entire academic experience improved by having better relationships with the faculty members at the School of Civil Engineering. Students explained that they initially had negative perceptions about their professors, however, the perceptions changed after participating in the program. Also, by knowing their professors, students felt more engaged in lectures and encouraged to participate. Interviewer #8 (Female) explained: "…so I asked some questions to Mentor 1, which was quite unusual for me, because I'm not that kind of enthusiastic student, but yeah I wasn't at all, Icarus made me realize that I actually can ask questions."

In addition, a big aspect of the program was to let the students understand what civil engineering is about, and the understanding becoming a practicing engineer is not the only option. Some students recognized that they now understand the academic path better and are considering a path in research was not something they would have considered otherwise. Two students commented:

> I know what engineering really is. I think it shows me what engineers in the workplace do but not only in the field but also in the research path. Working in projects like this or even just the lecturers, just seeing what they do every day is great. If I did it – if I wasn't sure about engineering and I got to know and it's not my thing, then I'd quit it. It's just good knowing what you're studying for, and all the possible options you have in the future kind of thing. That's what I got from Icarus. So pretty much what the profession do and that I can be one of them someday. [I#9]

> No. I mean, maybe I was too scared actually, because the other day I asked mentor 1 about what he was like in the industry, and why did you choose to do teaching - professor? He told me about some things, and then he was a totally different person, actually. He still wanted to give me some strategy and the way to go there, and be in the industry field and he told me about that, and he was more like not a mentor but just a brother. He was a really more than a mentor. [I#6Female]

Perceptions of Inclusion and Diversity

One of the most important and unexpected findings of the data collected, was the impact that the Icarus program had in inclusion and diversity. Marginalized students reported how the program made them feel, and how they use the program to have a voice in the School of Civil Engineering. It also encouraged them to be successful in their engineering career. Students explained how they were able for the first time to develop relationships with other students:

> Because now I've gotten to know people from engineering from outside my circle because I'm often with groups, with projects groups, often they have… well I think we are on to form long lasting friendships with them and also it could be because before Icarus I didn't have that kind of bonding experience. [I#10Female]

> …we also sometimes ask for each other's help, not only on Icarus space work but also on other stuff outside of Icarus. Sometimes that happens – we meet up pretty much at this time on this day at the Icarus room and lets us do this [coursework] together. [I#12International]

In addition, students explained that by being part of the Icarus program they developed a "Cohort feeling," usually in civil engineering, there are so many students in the lectures that students are not able to bond and have that. However, students felt that Icarus provided a cohort for them, they consider themselves as part of the Icarus family. As International student #11 commented: "After the exam we had a party and all the Icarus students went to the city and grabbed a beer. Yeah, it was good fun. I mean, yeah I think those people in the group are going to be really good friends until I graduate, I think they actually are the first real friends I have had since I arrived to Australia"

Furthermore, the explained that the Icarus cohort shared the same motivations and interests as engineers

> I keep saying self-motivations. Yes, and as I said, if I were in the first year of engineering, I actually was sitting in the lecture room for getting the degree - for getting credit, but as I do Icarus, with Mentor 1 and everyone in the Icarus project, I actually felt that all these people at least - these people knew what they want to do, and these people aren't here to just to learn something in the university, they –like me- are here to change the world, to have a voice, to care about what a good engineer needs to be" [I#10Female]

> Like as I was saying, everyone was closed in the first few weeks so I didn't know anyone. Now, I know them really well as people. Most importantly I feel

> confident that I can talk to other people and I can make friends that are different than me [I#9]

Finally, the Icarus program helped students to reinforce that they are good enough to do engineering. Several of them expressed how before Icarus they didn't feel they belong; they were demotivated to come to campus, and they were not sure about engineering being the right choice for them. However, the Icarus program provided that missing piece in their academic program that reinforced them to continue with their studies. As some students commented:

> At some point I did not really feel like doing University, I didn't - it stepped up the amount of effort required, and I'd gone through all of school courses. Sort of just sat without having to try very - fairly well in grades and stuff. Then Icarus happened and my motivation came back [I#6Female]

> I feel like I wasn't ready enough as an engineer, I guess that was my perception. However, the students that are gaining the most [from Icarus] aren't necessarily the students who will go and meet the lecturers on their own. The benefit is for students like me, we are scared, we don't feel we belong, I to be honest hated coming to Uni [I#7International]

The reinforcement helped especially female engineering students who had perceived barriers to be a successful engineer in a male-dominated field. Female student #4 explained:

> It also [The Icarus program] made me more confident…Because I just - I can talk to people a bit more clearly now, openly - not as before. Okay, I used to think that as an international woman in engineering, my voice didn't matter; I was scared of talking to my lecturer, now I feel he is my mentor [laughs]. But - yeah it'll help me be confident as well because I have been able to probe in the lab that my knowledge as good as anyone else's.

Another female student (#10) also commented:

> Umm, one of the interesting things I got out of it, was sort of confirmed like what I had experienced in engineering is not true. Like lots of women in these occupations find that there's a big barrier of them being a woman in a man's world. But I haven't found that. That's probably because my participation in Icarus. Like I don't think, oh I'm a female so I can't do it. That will never affect me anymore because guess what? I did it.

Discussion

Results from the data collected helped us to better understand students' initial perceptions of their experiences with Icarus. When students were asked about why they wanted to join an extracurricular program that offered them the option to use their spare time to participate in a voluntary research project, students expressed they were motivated to participate because they wanted to apply the theoretical knowledge obtained in the classroom into real engineering situations. This aligns with the perceived need for students to belong to their engineering program in their engineering identity development (Floyd-Smith et al., 2010).

The second most cited reason students provided was about the need to have a cohort-like experience and get to know their peers, something more difficult to achieve in their large engineering lectures. The need to interact with other engineering students in order to develop professional relationships can be also related to the engagement theory of self-belonging proposed by Allendoerfe et al. (2012) and D. Wilson et al. (2014), explained previously.

Another reason the students provided for their interest in participating in Icarus was the opportunity to explore and work on a research project of a topic of their choosing. Students wanted to study and use self-directed learning (Baxter-Magolda, 2004) to better understand a specific engineering topic and the opportunity to conduct research on it provided motivation to spend some time engaged in the voluntary program.

Overall, the Icarus program has shown to be very successful in the school of civil engineering. Students participating in the program were very engaged with the program, the research they conducted, and their interactions with their peers. Icarus has been shown to be part of the solution to the problem of the structure of higher education systems, especially in engineering, where students enrol in large classes and have minimal interaction with their peers and their instructors. Students participating in Icarus have reported that they feel they not only know and engage better with their peers, but also engaged more in their classes because they have been able to get to know some of the faculty members of the school outside the classrooms.

The Icarus projects were developed by academic mentors that spent time mentoring the students, and letting them have hands-on research experience and the opportunity to make mistakes and learn from the experience. Results describe how students were able to make comparisons between their traditional education, and the added value that the Icarus program provided to them which had a direct impact on the way they learn, on their motivation to engage in their courses and with their professors.

Finally results explained the positive impact that the Icarus program had on improving inclusion and diversity in the School of Civil Engineering. Students felt they belonged to the program and the University for the first time, and felt encouraged to have a voice, to speak up, and to demonstrate that their work is valuable and important for the field.

Further Implications

The goal of this paper was to present the initial perceptions of the students participating in the Icarus program, and also describe the program in detail. Results suggest that understanding the importance of this type of programs to students, and why it enables academic engagement for both students and mentors, can allow educators to encourage and support participation in these types of programs from inside the classroom. It is important to institutionalize Icarus as a successful program in the School of Civil Engineering as it is helping with students' engagement, sense of belonging, self-directed learning skills, and perceptions of inclusion. The program is providing students in the School with an option to participate in an extracurricular activity and also to learn more about an engineering topic that they care about.

The findings provide implications for practice regarding how to design better out-of-the-classroom interventions that allow hands-on application, promote more collaboration, and allow students to develop positive relationships with faculty members. The Icarus program is a voluntary program that does not reward students with credit, or any other type of

compensation, however it has had a remarkable positive impact in the School of Civil Engineering. Faculty members have also seen the benefit of investing their time mentoring students. They realized that not only students are more engaged in their courses, but also were able to execute several minor research projects that they didn't have the time before to conduct.

Acknowledgments

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