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The Development of Personal Growth, Self-Awareness & Graduate Attributes in Engineering & Design Factory Students – Part 1

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CONTEXT

Engineering, like many workforces, is adapting to the technological advances the world is experiencing which is creating new engineering roles as well as requiring more links between roles. This, therefore, is putting pressure on undergraduate students to enter a workforce that is constantly evolving and to quickly feel comfortable to contribute meaningfully. Currently, engineering education tends to focus heavily on technical teaching and practical experiments with little emphasis on work-ready skills. The use of student-centered teaching & learning pedagogies is essential engineering disciplines though are still assessed heavily on outcomes rather than process; with repetition of a skill seen as growth. This paper is an investigation into how a Level 7 engineering project and Design Factory Module can develop and enhance student's growth which in turn, can create students who can assimilate faster into the workforce.

PURPOSE

The purpose of this study is to understand the engineering educational approach to prepare students for industry and to record the progression of student's personal growth, self-awareness, and graduate attributes, which are measured against our observations.

APPROACH OR METHODOLOGY/METHODS

The Engineering project and Design Factory courses have industry connections and are believed to create the most change in personal growth of students. This study involves ongoing collection of student data from semi-structured interviews at the beginning, middle and end of year. The interviews collect data about the learners' profile, learners' progress, and employability skills self-assessment to analyse their competency throughout the course. As well as this, part of the Design Factory course assessment includes a personal development plan which measures the soft skill development of the students during their study.

ACTUAL OUTCOMES

Early indications show students want involvement in industry projects, participate in hands on exercises and practical learnings to gain work-ready skills. Students tend to rate themselves highly on their employability skills, until placed in a situation that is new to them. As more data is received (over a long term study) this study will help identify graduate attribute areas which require development and aid in identifying activities that work the best for student growth.

CONCLUSIONS

Reid and Ferguson state, "To develop and enhance student's growth, it is necessary to praise a student's professional learning – not just a student's intelligence". This study is a first step to building on this statement, by creating an understanding of engineering students needs in relation to future engineering employability.

KEYWORDS

Work-ready skills, Engineering Education, Student Centered Learning

Introduction

In the last few decades, there has been an increase in attention to the current educational framework of delivering engineering & design courses, which is academically demanding. The structure of engineering and design qualifications focuses strongly on technical (theoretical & practical) teaching and less on the guidance and support of students' personal growth. In terms of engineering assessment, an undergraduate student performance is assessed by standard approaches, for example assignments, tests and exams. However, minimal input of time and resources are invested towards non-academic exercises, which develop students' personal growth, self-awareness, and graduate attributes, which are broader and more encompassing than "employability," helping to develop academic and career competencies (Hill et al., 2016). In tertiary education, students' personal growth, self-awareness, and graduate attributes should be considered as an integral part in the study plan for engineering and design courses, as it can significantly impact the chances of attaining successes in students' future careers (Auðunsson et al., n.d.).

The structure of engineering and design courses are traditionally content-centered, and over the last decade there has been an increase in student centered learning that consists of interactive activities and blended learning pedagogies. To complement student centeredness, it is also essential for students to be engaged in varied forms of learning that strengthen their personal development (Belahmer, 2015, p. 194-198). Personal growth in the engineering context means to develop attributes such as, flexibility, self-confidence, a sense of responsibility, or enhancing engineering identity. It is extremely advantageous for learners to be involved in activities/exercises to develop their personal strengths, values, and skills. The importance of graduate attributes is increasing rapidly in international bodies such as higher education universities & institutes, the industrial platform, governing agencies, and accrediting sectors. Research has suggested that graduates' success rates in their jobs depends majorly on graduate attributes than on narrowed discipline specific academic content. It would be beneficial to have course's structured with assessment criteria focusing on students' awareness on graduate attributes and embedded in the learning activities for their development (Treleaven & Voola, 2008, p. 160-173).

In order to create graduates with skills ready for industry, higher education institutions are adapting 21st century teaching approaches, most commonly using activities related to Project-based Learning (PBL) and Work-Integrated Learning. These two learning pedagogies are useful approaches as they achieve the desired content knowledge while creating opportunities for personal development such as self-confidence, self-esteem, being self-aware and developing work ready skills.

Development of Personal Growth, Self-Awareness & Graduate Attributes

The planning of academic curriculums of any undergraduate programme is centered upon graduate attributes/work-ready competencies. These graduate attributes demanded by industry in students can be categorised in two distinct groups: technical & generic. The generic attributes include soft skills, which graduate students must attain irrespective of the area of study. Many educational platforms, such as polytechnics & universities have redefined graduate attributes that can assist in learners' personal development, flexibility, and sense of responsibility towards multi-disciplinary projects (Moalosi et al., 2012). Personal growth is vital in the academic world, as it is a process of establishing awareness and identity of yourself, that allows a student to build on self-esteem, confidence, motivation, and professional skills. Personal growth in learners incorporates cognitive components such as, awareness to change, believing that change is possible, and delivering positive behavioural components by taking the initiative to accept challenges (Patanapu et al., 2018).

Self-awareness is another component that plays a crucial role in learners. As a student, it is important to be aware of their own strengths and weaknesses, acknowledging the shortcomings in the field of study and employment will help them to learn, embrace and succeed. As educators, this can take form in many ways such as setting self-awareness goals and objectives, which gives students' motivation to succeed and create belief in themselves (Positive Action, 2020).

Development of Employability Skills and Engineering Curriculum

Mills & Treagust, (2003), suggested that the review of accreditation criteria from many educational bodies around industry requirements from engineering raised issues such as:

- Engineering curricula is only focusing on theoretical concepts around science and technical courses without providing sufficient integration that can relate to industrial practice.
- Minimal design experiences are delivered to learners throughout their programme
- Graduates are lacking in teamwork, communication and interpersonal skills when entering the workforce
- Most of the existing teaching and learning strategies are traditionally driven in engineering and programs need to become more student-centred (Mills & Treagust, 2003)

The use of pedagogical approaches such as Project-based Learning and Work integrated learning address some of these issues. The use of these pedagogies enables active cooperation and interaction that create opportunities for learners to gain technical and personal skills. Uses of PBL & WIL creates a student-centered learning environment in the classroom, as it allows students to acquire knowledge by working and solving an authentic industry problem. The problem is created so that students discover what they need to learn, to address that problem and resolve the problem. Specifically, these pedagogies are an effective teaching tool, that motivates student and clearly demonstrate the development of teamwork and communication skills in learners (Ríosa et al., 2010, p. 1368-1378).

Reflective Practice (Learner Profile & Employability Skills-Self Assessment)

This research paper centres around engineering students and their understanding of the skills they need when they go into industry. It involves finding out from students their awareness of graduate attributes embedded in their degree, what they believe is important and how they rank themselves on what industry believe are important. It also asks students the teaching and learning methods that they believe work for them in learning engineering content and developing industry skills. To achieve this understanding two tools have been developed, a learner profile questionnaire and an employability skills self-assessment survey. It involves ongoing collection of student data from semi-structured interviews at beginning, middle and end of year, (Engineering Project students only – 4 interviews) (Design Factory and Engineering Project Students – 5 interviews). The interviews collect data about the learners' profile, learners' progress, and employability skills self-assessment to analyse their competency throughout the course. The learner profile assists in gaining the information around who the learner is, their background, culture, and awareness around graduate attributes.
The employability skills self-assessment survey is based on attributes identified by the ministry of education (New Zealand Ministry of Education, 2019) and students reflect and rank themselves on their ability with the skills (twice in the year).

Methodology

With a growing emphasis in higher education institutions in enabling personal growth and learners' employment, educators have spent extensive time and effort to create collaborative projects and learning activities with the objective to allow learners to gain personal skills and graduate attributes in their final year of engineering & design qualifications (Rowe & Zegwaard, 2017, p. 87-99). This research project is continuing this theme, with the first step to understand the current approaches that prepare students for industry and to record current perciefved student employability skill progression. To do this we are gathering data from students who are studying within two courses; Engineering Project, a level 7 course which is made up of students across three vocational engineering disciplines, Civil, Electrical & Mechanical. We have also included students from the Design Factory course, which has students from the same engineering disciplines but also includes students from Information Technology, Media Arts, Business, etc. All the students participated in the research are pursuing level 7 qualifications in Engineering.

The sequence of collecting data was conducted from semi-structured Interviews that incorporated the following tools: Learner profile questionnaire & Employability skills self-assessment survey.

- Recorded interviews of engineering students BEFORE they start Design Factory and Engineering Project modules.
- Recorded interviews of engineering students during their course once in each semester.
- Recorded interviews of engineering students at completion of the two courses (Due to this research being focussed on personal development we are not considering interviewing employers at this stage).
- The employability survey is completed twice by the student. Once within the semester and once at the end of the course

The data collection varies slightly if a student is completing both Design Factory and the Engineering Project course at the same time compared to if they are doing the courses in different semesters. The first stage of data collection was to implement the learner profile questionnaire during the first week of semester 1. The following is a sample of questions that were created to gather information around students' background and career aspirations:

- How would you describe yourself, in terms of culture and hobbies?
- What do you know about graduate attributes?
- What do you think are the work ready skills a graduate engineer needs?
- What do you think will help you the most in achieving these goals & barriers?
- Tell us a story about teaching and learning activities that you have experienced in the past that have helped your learning the most (and the opposite)

The second stage of data collection was to implement the employability skills self-assessment survey in the mid-semester for the students. The employability attributes targeted for the survey were: Communication Skills, Teamwork, Self- management, Resilience and Engineering Knowledge. The students were asked to choose the most suitable option (Needs work, Can do, Can do well, and Very good at this) and be reflective by providing real life examples, where they have demonstrated the specific graduate attribute.

Design Factory & Engineering programmes offer a range of learning experiences for students seeking to prepare for the future workplace – such as:

- Industry Breakfast: two networking sessions at breakfast, which students organise and run where they project information and ask for feedback from industry

- Lunchtime Learnings: 30 Minutes of Lunchtime Learning with Industry partners around innovations and real-world problems
- Design Factory Gala: A final presentation of the 15-week project in the form of a “sell” of the solution presented to 60 – 100 stakeholders (industry, educators, colleagues.
- Site Visits/Field Trips: Industry tours to give real-world exposure to students
- Guest Lecturers: Inviting professionals/employers from industry to share current engineering practices & industry demands for students
- Student & Industry Projects – Embedding connections via industry projects for students

All the external engagement of students involve stakeholders, industry partners, community partners, government, and employers, whose input into curriculum is vital to ensure it remains relevant to the needs of employment markets.

Quantitative data is analysed through visual graphs and analysing for patterns.

Qualitative data is analysed using thematic analysis (Braun & Clarke, 2006, p. 77-101). Data is shared amongst the researchers in a visual way with important key points shown. Each student may have 20-30 individual data points. This data is then clustered according to similarities in words or intent (coding). Each cluster is then turned into an insight. An insight is a summarised statement of many data points, written from the students’ point of view while also including an action. Insights are then merged further to create themes. Themes are reviewed against each other, the data and the original research question to ensure there is a compelling story.

Limitations

As this is the start of a longitudinal study there is only a small amount of student data (9 students) though this student data does represent 66% of all level 7 engineering students. This data set will grow per semester as the study progresses.

At the time of writing, this final stage has not been completed yet and will not be completed until final questionnaires and surveys have been carried out, which are currently in progress.

Lockdowns due to the pandemic have meant that some opportunities to develop their personal growth did not eventuate (i.e. networking events).

Lockdowns have Influenced students’ wellbeing which may have an indirect effect on some of the responses in the second half of the year.

Results & Discussion

Themes from the Learner Profile Questionnaire:

The learner profile questionnaire from students were analysed, and data points were clustered into themes. The most important themes related to this study are explained below.

The first theme revolves around students and their connections with industry. Students value industry connections as they believe it will help them to attain employment once graduated. Engineering students also have a fear that they won’t be useful on the job, so it is important to them that they have confidence in what they are learning and are exposed to many different engineering situations.

Summarised insights relating to this theme are as follows:

- Students want to connect with industry during their engineering programme – as they believe this will lead to career opportunities.

- Students want to be confident in their technical ability, so they are useful for their employer as soon as they start work.

- Students believe developing high quality professional engineering conversational skills will aid to gaining employment.

- Students want connections with industry so they can see engineering process and application in the real-world context

The second theme relates to the approaches used to prepare students for industry. Students recognise and value a range of assessment approaches and recognise employability skills are embedded in these approaches. This theme was based on the following insights:

- Students value a variety of assessment types such as formative & summative integrated in their classroom learnings and believe it helps to develop them as a professional.

- Students value a variety of real-life examples, guest lecturers and site visits to familiarise with industry practice and grasp the teaching content easily.

- Students have identified that the Design Factory module is a great teaching & learning resource to develop graduate attributes, industry connections, and professional skills due to its real-life project.

- Students identified project related exercises helps in better learning and development of graduate attributes as professionals.

- Students found that time management has been the strongest barrier for them to succeed in their studies because of competing pressures such as work and young family

A final theme would be the students' belief that technology will continue to advance, and they will need to continually be learning to stay current. Being a lifelong learner was important to them.

- Students believe that engineers of the future will need well developed soft skills to be adaptable and practical as technology will always advance.

As an aside, there are a few themes that don't relate to this particular study that we found interesting. We would like to acknowledge the following one in particular:

- Students found learning situations challenging when they lost trust in the system to provide a quality education and had to take it on themselves, such as; when the tutor did not know topic well enough, or the technology wasn't capable, or the tutor wasn't adaptable.

The reason we would like to acknowledge this is that if students lose trust, then they focus only on grades and not on continual development that is required for effective integration into industry. As mentioned, at the time of writing, these are initial themes and insights. The researchers will retheme and refine as more data is collected whilst also including the quantitative data from the employability surveys.

Employability Surveys

Quantitative data from the employability survey was collected from the students. The students were required to rate themselves on the following graduate attributes: Communication, Teamwork, Self-Management, Resilience and Engineering Knowledge. The following show an excerpt of data that related to the themes generated from the learner profile questionnaire.

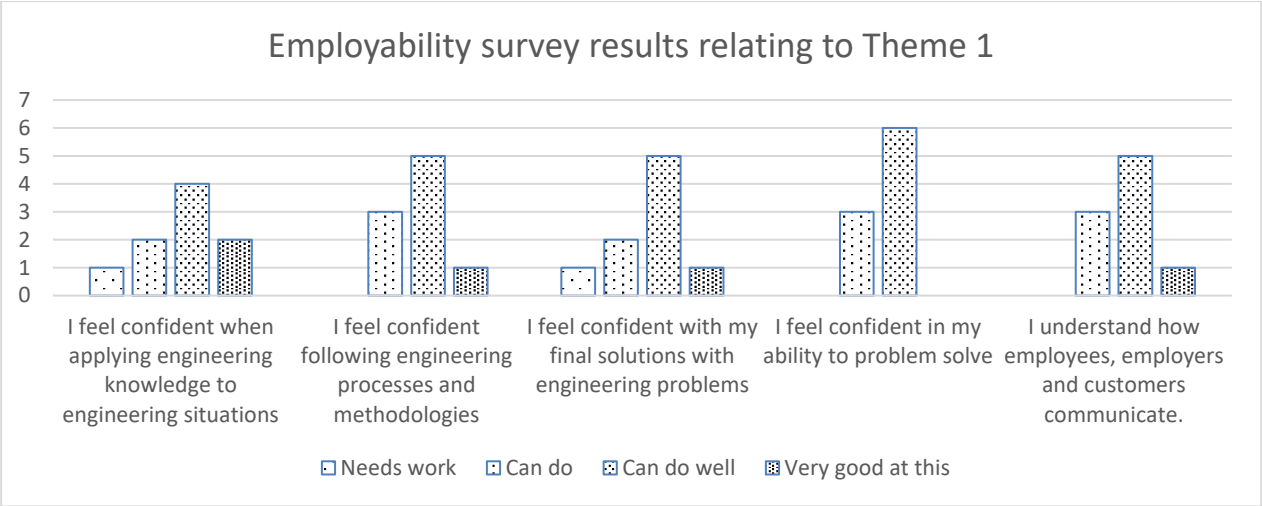

Figure 1: Demonstration of the results for theme 1 – students and their connections with industry

The survey results from figure 1 show that students have a varying confidence in applying engineering knowledge to engineering situations and feeling confident in their abilities with engineering processes and methodologies. These questions all had more students ticking the "needs work" or "can do" boxes than other questions. Students believed they had a good awareness of how communication within an organisation works, though there are still a few at the "can do" as opposed to "can do well". These results compare well with theme 1 in the earlier section, which was summarised as students not being confident of their skills once in the workforce and wanted opportunities to connect with industry to build their industrial knowledge.

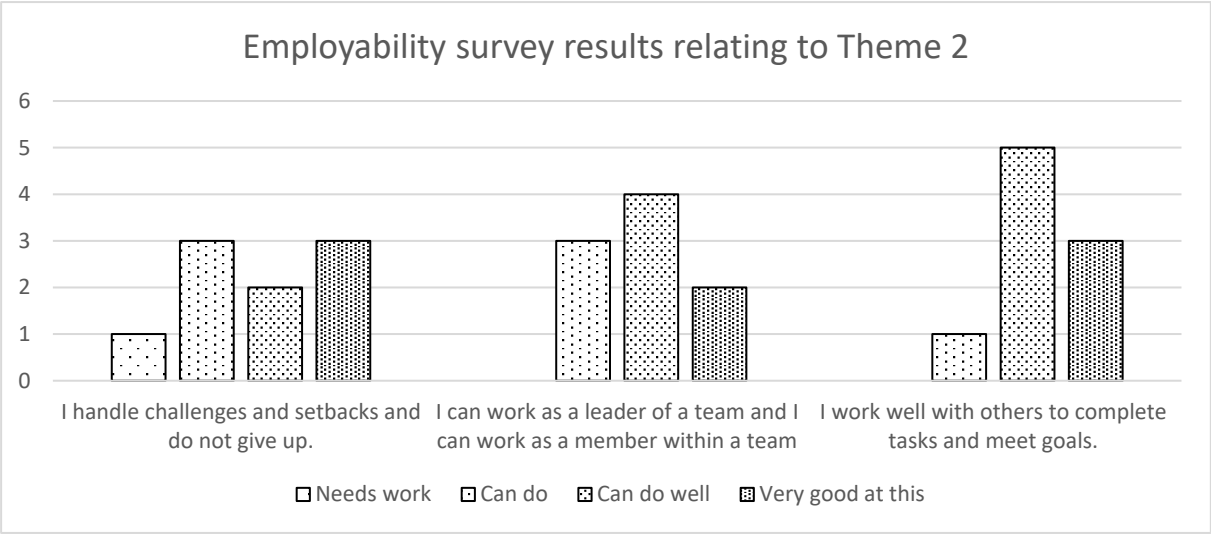

Figure 2: Demonstration of the results for theme 2 – approaches and recognising employability skills

Students in general believed they had very highly developed employability skills. Students ticked "can do well" or "very good at this" for many questions. We will be interested in the analysis of the second round of surveys to see if students become more aware of the real-world context of employability skills. The results in figure 2 show that students have a varied ability to be resilient. This shows us that it is important for students to apply engineering knowledge within their educational settings without fear of feedback. The second set of results in figure 2, show that students have a varied ability to switch roles from leader to team member in a group but they thought that they were effective at working within a team.

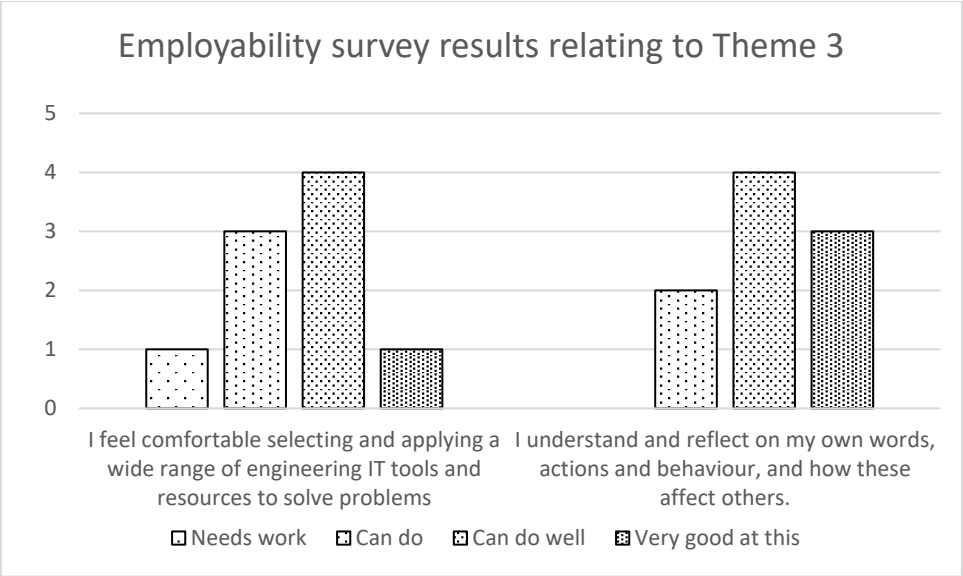

Figure 3: Demonstration of the results for theme 3 – technology and lifelong learning

In the earlier section it was stated that students know that technology will advance throughout their careers, and they therefore recognise the need for lifelong learning. Figure 3 shows that not all students surveyed felt confident in the use of technology though and some thought they can just do it. Pleasingly, reflection does seem to rate high as an engineering skill which is a key aspect of lifelong learning.

Conclusion

Overall, the authors of this research have collected valuable feedback from the first half of the year, which has indicated the students urge and aspirations towards industrial connections for professional development.

From the first round of feedback the following themes have been identified:

- Students want connections with industry and engineering application while studying so they feel confident when they go into workplaces.
- Students value a range of educational approaches that link clearly with employability skills
- Students want to attain lifelong learning skills to help keep up with technological advancements

The researchers note that students still believe they need more interaction, to develop confidence, this will become clearer as sample size grows.

This is the first step of a longitudinal study, and we expect insights, themes and survey data to become more refined over time.

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