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# The Progression and Development of Graduate Attributes in Undergraduate Students and Graduate Engineers

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## ABSTRACT

### CONTEXT

Globally, engineering is facing more complex challenges in their day-to-day practice. Simple tasks have been made more complex for a variety of reasons including technological advancement, improved sustainability practices or responding to pressures of the ever-changing world (such as the recent pandemic). Engineering programmes and courses have responded in recent years by emphasising the work ready skills within the curriculum. This paper is a continuation of the paper presented in 2021 by Khanna & Bigham, which sets to understand the progression and development of graduate attributes within engineering students of the Bachelor of Engineering Technology at Wintec Te Pūkenga. The additions in this paper (from 2021) are the inclusion of 2022 undergraduate data which validates 2021 findings.

### GOAL

The goal of the paper is to continue the collection and analysis of student feedback received in 2021 and 2022. Graduate data is beginning to be collected but will not make it into this paper.

### APPROACH

The collection of data and approach continues from Khanna & Bigham, 2021 by conducting 4 interviews over a period of 1 year (2 Semesters) for Engineering & Design Factory New Zealand students. The interviews incorporate a learners' profile questionnaire and employability skills self-assessment to analyse the progression of students throughout the year. Graduated students will also be interviewed using the graduate profile questionnaire to extend the measure of progression of students becoming professionals (This graduate data will not make this paper)

### ANTICIPATED OUTCOMES

From the student feedback in 2021, the initial data of 2022 is comparable and depicts learners are career-minded individuals and have strong proposition to engage in activities that incorporates projects and industry relevant exercises to improve their professional competencies. Mostly, students recognise the need for employability skills, and their own growth in areas such as teamwork, communication, self-management and resilience. They tend to rate themselves quite highly in these areas, though they also recognise they need more opportunities to develop these skills while studying, especially in the various forms of assessment

### CONCLUSIONS

This paper provides an analysis of student feedback that demonstrates the efficacy of professional attributes in the curriculum, and not just focus on theoretical aspects. This paper identifies the critical areas of development of students' graduate skills and hence allows us to respond as educators.

### KEYWORDS

Graduate Engineers, Engineering Education, Work integrated learning.

# Introduction

The development of academic regulations focusses on integrating industry engagement to enable competent graduates in the engineering world. There are increasingly stringent regulations and guidelines within engineering workforces and educational institutions must respond to this to produce employable graduates. This engenders the critical need for feeding the national affluence of successful industrial representation for the countries around the world (Hill et al., 2016). The graduate competencies therefore should not be seen as being independent from the engineering curriculum because engineers are required to demonstrate generic graduate attributes in their field of discipline. The industry relies significantly on how their professionals are showcasing the generic graduate attributes such as, communication skills that must be expressed in every engineering course as a requirement to exercise effective communication and deliver design and problem solutions, while collaborating as a team. The traditional approaches of designing curriculums have always focused on the engineering topics, formulas, processes, and literature. The graduate skills and attributes were never taken into account as a substantial component in graduates. Over the last decade there has been an increase in concentrating on the student-centered learning practices that consists of engaging activities and blended adult-teaching and learning pedagogies. In order to complement the student centeredness, it has brought in the drive of student engagement in varied forms of learnings. The classroom sessions have integrated exercises and assignments that acquire communication, time management and teamwork attributes (Vilapakkam Nagarajan & Edwards, 2014). The industry/employers express that a graduate engineer should not only demonstrate skills relevant to their discipline but also demonstrate commitment, integrity, and honesty. This caused the shift to the personal growth in the engineering context, creating the opportunities to develop the soft skills such as, flexibility, self-confidence, a sense of responsibility, or enhancing engineering identity.

The ongoing technological advancements has made major impacts in the last few decades to engineering profession, that causes the drift in education to emphasise on work ready skills to develop competent and responsible graduates. The progression of undergraduate students and graduate engineers comes from the correct perception of the graduate attributes desired by the industry and ensure it has been implemented in best practice. In Charles Darwin University “creativity” is listed as a graduate attribute with the corresponding employability skill such as being initiative and enterprise skills to develop innovative and workable outcomes. This defines the dynamic changes in the global aspects of engineering and brings light that progression in the career is permanent (Lee & Chin, 2017).

## The Progression of Graduate Attributes in Undergraduates & Graduate Engineers

The demand of competent graduates with specific engineering discipline knowledge is rapidly increasing, to cope with the ongoing changing work environments. In response to this, there is a growing trend in tertiary education to closely monitor the integration process of graduate attributes in coursework. The engineering curriculum, in this paper, was built with a graduate profile which informs learning outcomes and employability skills within each course. The graduate students must not only pass the learning outcomes and each course but must demonstrate the certain attributes to show they are capableL: e.g. solve a broad range of engineering problems, communicate effectively, to collaborate in teams, are critical thinkers, and demonstrate sufficient information technology skills. Integration of these skills in the curriculum demands a new approach to learning, teaching and assessment methods. However, the drift of change is diverted to measure and track the progression of graduate attributes in the students. It has been found to benefit for both staff, students and graduates. The graduate attributes in undergraduates are now captured in the course descriptors, encapsulating the set of knowledge, professional skills and values to foster responsible and competent individuals. The approach of tracking the progression of undergraduates sets their educational pathways clearly to employment. With the ongoing engagement of graduate attributes, research has shown that the students are more aware of the engineering knowledge, skills and values (Moalosi et al., 2012, p. 40-46). The graduate attributes are built upon hands-on and interactive educational learning, which helps the reform of curriculums and settings of the classrooms.

### Using the Learner Profile & Employability Skills Self-Assessment Questionnaires

The most important aspect of education is student achievement, which is dependent on the process of reflective practice, this includes receiving feedback that benefits both the educator and student. The collection of feedback expands the perspectives in a persuasive way and give clear insights to form work-ready graduates (Helmke, 2015). The perception of students through reflection-based activities is an important step to achieve qualitative teaching and learning. Studies have shown that student feedback delivers positive impact towards the teachers and students' connection, which helps to the meet the needs and deliver successful outcomes for the students. In research from Khanna and Bigham 2021, this paper continues the approach of gathering feedback on student awareness of graduate attributes embedded in their engineering qualification. Also, the students are required to rank themselves on their own interpretation of employability skills, which must be supported by examples where they have delivered the skill. To facilitate the reflection of students' feedback, this study adopts the questionnaires from Khanna and Bigham (2021), learner profile & employability skills self-assessment. The data collection is done through the format of semi-structured face to face interviews with the students at the beginning, end of semester 1 and end of year. The focus group for the collection of feedback is level 7 students for Engineering Development Project (Bachelor of Engineering with Technology) and Design Factory, which facilitates the following number of surveys for each module; engineering project module consists of 4 interviews (start and finish) and design factory also consists of 4 interviews (start and finish).

The questionnaires are utilised from the research of Khanna and Bigham (2021), it is collecting data about the students' background, culture (learner profile) and awareness around graduate attributes (employability skills self-assessment). Student responses from the questionnaires are then analysed to specific themes and insights that encompasses the graduate attributes and targeting the areas for improvement. This year, the research has been extended to also include the graduate feedback through the learner profile questionnaire, to capture their thoughts and viewpoints while working in the industry, but due to the time constraints the responses would not be able to make into this paper.

## Methodology

From research, it can be stated that there is a rapid increase of focus and regulation set by universities and institutes on the graduate attributes. These work-ready skills have emerged as an important outcome of learning in the current setting of industrial requirements. With only disciplinary knowledge, it is not sufficient to attain employment. With the ongoing changes to technology and advancing innovations, employers expect the graduates to efficient in changing work environment, and proactive towards new learnings. The employment market relies on graduates that delivers adaptability, flexibility and demonstrate strong employability skills, that can be applied in a variety of engineering context. From Khanna and Bigham (2021), the two courses are Engineering Project, a level 7 course which is made up of students across three vocational engineering disciplines, Civil, Electrical & Mechanical. The second course is the Design Factory module, which has students from the same engineering disciplines but also includes students from Information Technology, Media Arts, Business, etc. These courses have continued to deliver collaborative projects, student centered learning exercises, interactive activities and approaches. All these engaging activities builds confidence to students by making them to work in groups, demonstrate leadership, management, and communication skills through presentation to the clients/stakeholders (Chandna, 2015).

As the researchers, we continued the investigation from 2021 across the 3 distinct engineering disciplines, Civil, Electrical & Mechanical. As mentioned above, the participants are the students from level 7 engineering (full year) and DFNZ (single semester) modules. The objective is to track the progression of undergraduate students on their development and understanding of pre identified graduate attributes. The sequence of data collection and the questions created for the learner profile & employability skills self-assessment questionnaires is retrieved from the procedure set in the research of Khanna and Bigham (2021) shown as follows:

- Undertake 2 semi-structured interviews from engineering and DFNZ students at the beginning of semester 1 (1 for Learner Profile & 1 for Employability Skills Self-Assessment Questionnaires)
- Undertake 2 semi-structured interviews from DFNZ students at the end of semester 1 (1 for Learner Profile & 1 for Employability Skills Self-Assessment Questionnaires)
- Undertake 2 semi-structured interviews from engineering students at the end of semester 2 (1 for Learner Profile & 1 for Employability Skills Self-Assessment Questionnaires)
- Analyse the data using thematic analysis (Braun & Clarke, 2006) and quantitative measures
- Compare the analysis to 2021 findings to validate and identify new themes

As the research demonstrates in Khanna and Bigham (2021), this study continues to implement the following student-centered learning activities, industry engagement sessions and project-based exercises:

- Design Days: Students work in teams to build and demonstrate prototypes to staff
- DFNZ Gala Event
- Educational tours of the industry
- Inviting Guest Lecturers to classes
- Industry Projects for Students

Industrial engagement with students is essential to incorporate real-world context in the curriculum of the qualification. The tertiary education providers are driving towards the change of giving students industry experience, with no mark allocation. The integration of industry related programs has minimal effect on students, due to no mark allocation, therefore we as researchers also proposes student projects and industry tours (include case study reports) to make students learn and build connections. Also, as this is a longitudinal study there is only a small amount of student data took part in the study (11 students). This data set should grow per semester as the study progresses in future.

# Results & Discussion

### Themes and Quantitative Data from Learner Profile Questionnaire and Employability Skills Self-Assessment Questionnaire:

Using the thematic analysis approach from Khanna & Bigham (2021), the questionnaire from students were analysed, and data points were clustered into themes. The clustered themes were analysed amongst the researchers according to similarities in words or intent (coding). Each cluster is then turned into an insight. The insight is a summarised statement of many data points retrieved from the students' point of view while also including an action. Lastly, these Insights are then merged further to create the themes. Themes are reviewed against each other, to compare with the original research question and to ensure there is a compelling and cohesive story coming out from the students. Also, the quantitative data is also presented from the employability skills self-assessment survey that highlight the responses from the students around their understanding on graduate attributes.

Theme 1: The first theme is about students and industry connections. This theme defines the value of industry connections, and impact it creates on the students. The students are strongly demanding industry networking activities, sessions, and projects, which can help them attain suitable employment when they are graduated.

Summarised insights relating to this theme are detailed as follows:

- Students want more connections with industry, as they don't have networks or existing connections (this is especially true of international students)

- The goal of an engineering student is to find the ideal engineering position that pays well, and where they can apply their knowledge and graduate attributes attained in the qualification

- The best learning experiences are when students can put their knowledge into practice into the engineering world.

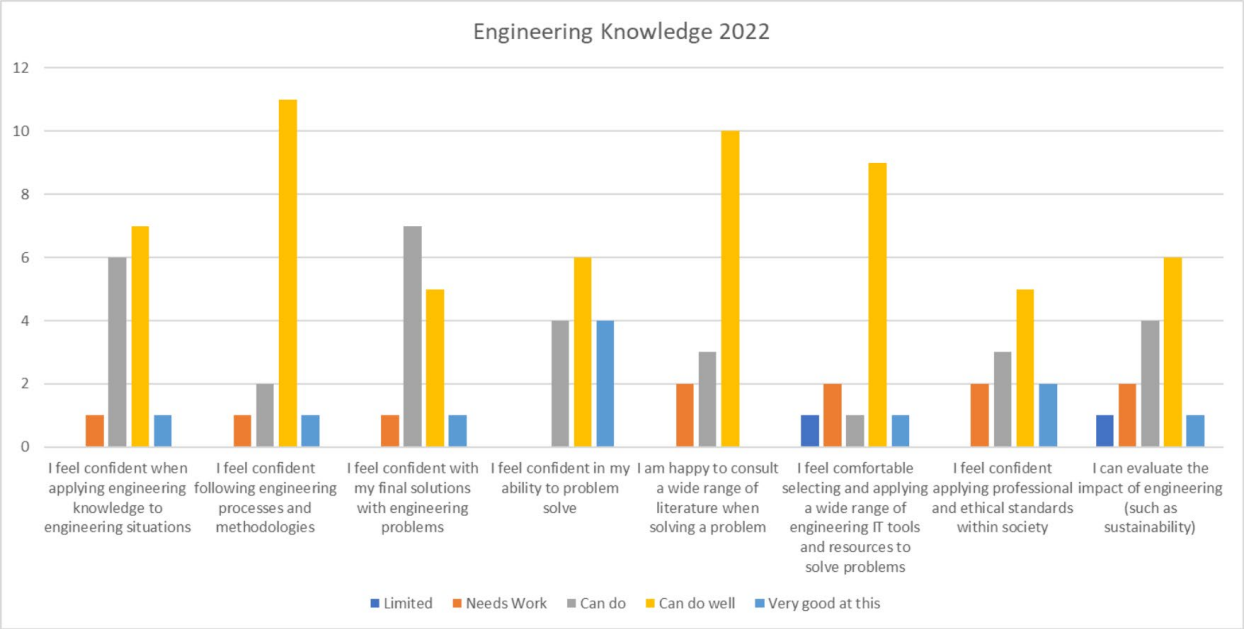


**Figure 1: Demonstration of the results for theme 1 – students and their connections with industry**

The employability skills self-assessment survey results shown in figure 1 states that students have strong confidence in following engineering processes and methodology with 11 participants stating that they "can do well". The highest participant rating of 11, ties in well with the last insight of theme1, which states that students find their best learning experiences, when they can put their engineering knowledge into practice. The results also show that students are confident with their ability of problem solving, with the highest rating of 4 for "very good at this", 6 for "can do well" and 4 for "can do". This shows that students believe that problem solving is an integral aspect of engineering practice and experience and must be acquired with full attention.

Theme 2: In 2021 there was a theme around using different teaching and learning approaches to prepare students for industry. Students recognised and valued a range of assessment approaches. In 2022, there were only 2 pieces of evidence to support this. One student enjoyed courses that took on a project where work was allocated throughout the day while another student discussed alternative assessment methods that mimicked real life. No new insight can be added from 2021 and the researchers will use these findings when ideating on course alterations.

Theme 3: The third theme reflects on the students' belief around the development of technology, and how it will continue to advance, and they will need to continually be learning to stay current and updated. Being a lifelong learner is the most critical and significant attribute, when graduated.

Summarised insights relating to this theme are detailed as follows:

- Students believe that the engineers of the future require the ability to continually learn. Technology (e.g., software) and technical knowledge will continually advance which will result in new engineering fields.

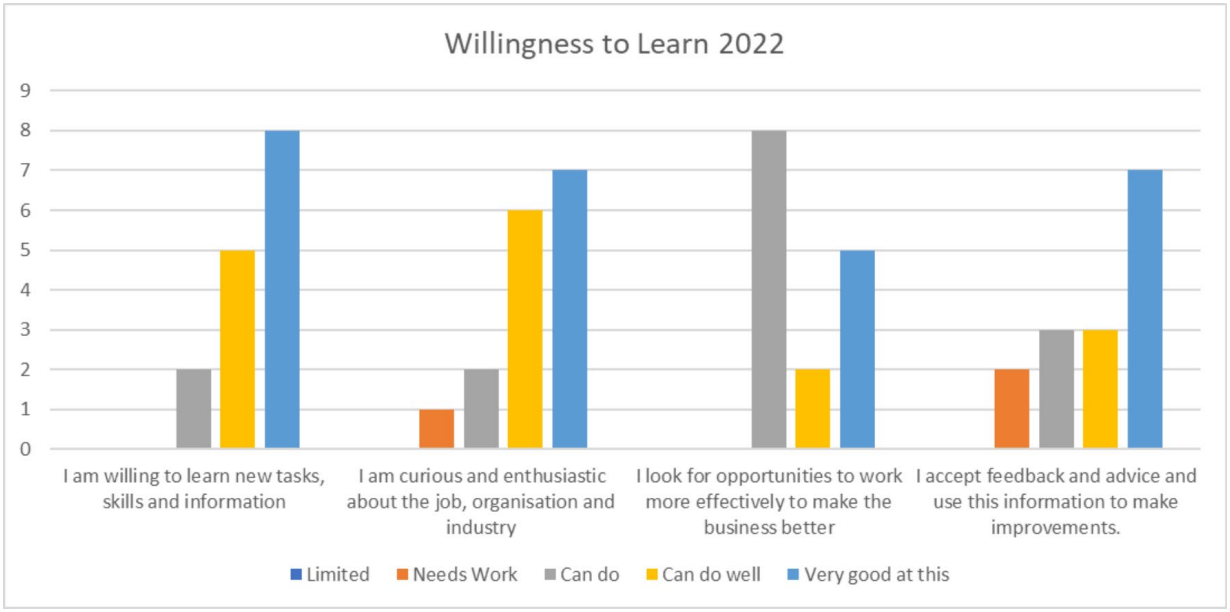


**Figure 2: Demonstration of the results for theme 3 – Students' belief for the Engineers of the Future**

The survey results show that students strongly believe that engineers of the future should be willing to learn and adapt to new technologies, to keep growing into this changing world. From the results in figure 2, it is strongly evident because 8 students have chosen the "very good at this" option for being willing to learn new tasks, skills, and information. Also, 5 students have chosen "can do well" option, with none of them selecting "needs work" or "limited". This is a significant aspect that shows students mindset and belief that you must exhibit the willingness towards the ongoing rise of innovation and technological developments in engineering.

Theme 4: A new insight with the 2022 data was that while students didn't know much about the embedded graduate attributes (same as 2021), they are very aware of certain attributes that they believe will help them be successful in an engineering career. The insights that led to this are the following:

- Many students were unaware that Graduate Attributes are embedded in their programme (in 3rd year) despite being introduced in handbooks and inductions. (This is the same as 2021)
- From the students' perspective, the most important and desirable professional skill is communication. The ability to communicate professionally is significant to make and be the change in the engineering world
- Teamwork is an essential work-ready competency as society needs engineers to work as a team.
- Engineering students believe that the key attribute they need while studying is to have a positive attitude to learning as they are aware, they are going into a job which has a large amount of responsibility. Students are therefore aware of the professional skills they need that support their positive attitude such as time management and self-management.

Students have summarised communication, teamwork and a positive attitude as essential attributes for a graduate engineer. Therefore, if courses provide activities and assessments in a way that promotes these behaviours then students will be motivated to participate. If these attributes are also explained clearly (i.e. explain "why" an assessment is being done in the way it is), it allows students to value the assessment approach and deepens their learning.

While students understand communication skills are important, they aren't confident with their communication which can be seen in figure 3. In most cases students are at "can do" so promoting ways to raise this confidence within the classroom would be helpful.

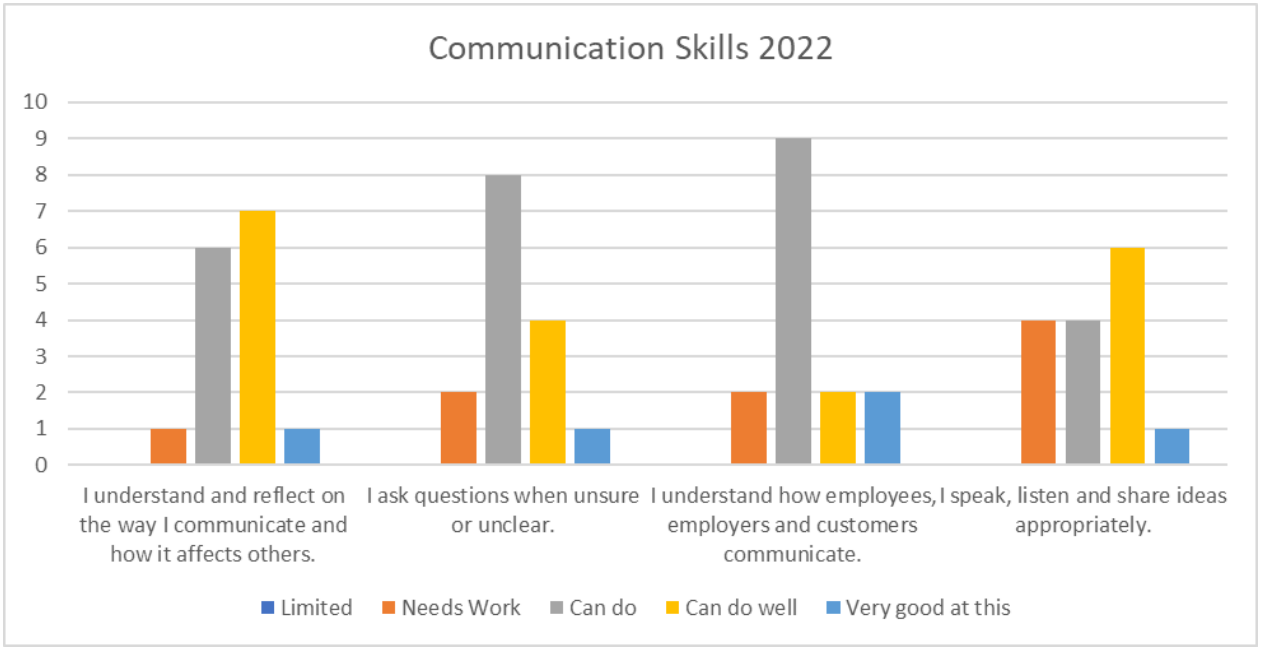


**Figure 3: Demonstration of the results for theme 4 – Students' views on the communication skills**

Other data show that students believe they have good teamwork skills overall, able to work within a team and lead as they need and are motivated to succeed. One interesting change from 2021 is students feel that they don't use their initiative as much as they did.

With more at the "can do" stage than previously. This may be due to COVID, and the recent surge of online learning removing the diverse opportunities they used to have in the classroom and practical environment.

Theme 5: As with 2021, the fifth theme of students losing trust in the system, or lacking support is also worth noting (even though this is not related to the intended outcomes of this study):

- Students have identified that supportive educators with strong focus and practical learnings are most effective in meeting their goals
- Students found learning situations challenging when they lost trust in the system to provide a quality education and had to take it on themselves

While not directly related to employability skills, in phase 2 of our research where we ideate on activities and assessments which support students in their attribute growth, these insights become important as activities (ideas) will need to be able to be supported by people and processes administering the ideas (students, staff, systems, industry).

# Conclusion

Insights generated in 2021 were validated by the data received in 2022:

- Students' believe that technology will continue to advance, and they will need to continually learn to stay current. Being a lifelong learner was important to them.
- Students value a range of educational approaches and assessment tools that link clearly with employability skills
- 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.

A fourth theme was also generated and was consistent with the 2021 data.

- Students didn't know much about the embedded graduate attributes they are very aware of certain attributes that they believe will help them be successful in an engineering career.

With the data collected and the themes identified, we can now respond with interventions which will make the learning environment (activities and assessments) engaging and motivational for the student while preparing them for the engineering working world.

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