Integrated Pathways: Connecting the Disconnected

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SELECT SESSION

C4: The role and impact of engineers and the engineering profession in the wider community

CONTEXT

This paper presents a program that has been developed to provide a pathway for students from secondary school into the New Zealand Diploma of Engineering (NZDE). In New Zealand, the Government has highlighted that there is a deficit of engineers going into industry at level 6 and 7 (Tertiary Education Commission, 2010), which will have a serious impact on NZ productivity in the years to come. To address this issue a NZ ITP and two local Hamilton secondary schools formed a partnership that would provide a meaningful pathway for level 3 students that would allow access to tertiary study and industry beyond.

PURPOSE

This program of study needed to take students who had disconnected with maths and physics and to connect them with engineering concepts in a contextualised manner and to provide them with entry into the NZDE. While the focus of this program was on year 13 students, this program also needed to provide opportunities for target groups such as Maori and Pacifica and Women, to engage with the world of engineering that would enable them to pathway into tertiary study. The first pilot of this program was run in 2016.

APPROACH

To develop this program, it was necessary for teachers from school and Wintec to work closely together to develop a model that would support these aims. To do this we developed a fully integrated 3+2 model, where students would participate in a contextualised program of study for three days at school. To compliment this the students attended Wintec for 2 days and were enrolled in Level 3 Trades Academy courses that would support the teaching at school.

RESULTS

From the first running of the program in 2016, out of the 15 students enrolled from Fairfield College, 9 achieved NCEA level 3 (achieved 80 credits. Out of these students all 9 of these students then enrolled in the NZDE.

One of the offshoot benefits from this program has been the learning and professional development that has come from teachers from both school and ITP moving into each other's environment to teach. One of the main findings was that many students reported that without the experience and appreciation of the course they would have left school without a clear goal or direction for their future.

CONCLUSIONS

Generally, this program has worked well and has managed to provide a pathway for students into the NZDE. It has also provided some unforeseen benefits.

KEYWORDS

Integrated programme; contextualised learning; 3+2 model

Introduction

In New Zealand, the Government has highlighted that there exists a deficit of engineers going into industry with level 6 and 7 qualifications (Tertiary Education Commission, 2010). This deficit has been highlighted because it will have a serious impact on NZ productivity in the years to come. To address this deficit in engineering graduates Tertiary Education Commission (TEC) developed the Engineering Education 2 Employment (EE2E) campaign (http://engineeringe2e.org.nz/, 2017), to promote engineering careers within schools predominantly. Waikato Institute of Technology (Wintec), and two local Hamilton secondary schools - Fairfield College, and Fraser High School, formed a partnership that would enable level 3 students access to tertiary study through the New Zealand Diploma of Engineering (NZDE) and industry beyond. This paper will focus on the development of this programme, its aims and objectives, from both Wintec and the school's perspectives. It will also look at the first intake onto the programme, the issues that were faced and what has been learnt from them, and how that has shaped the development of the next phase of the programme.

Purpose

In 2010 the National Engineering Education Plan (NEEP) Project put forward a national plan for ensuring that the right numbers of the right types of graduates are produced to meet New Zealand's needs (Tertiary Education Commission, 2010). Table 1 below shows the areas where the NEEP project projected that more graduates would be needed if New Zealand were to be an Innovation led economy.

Table 1: The deficit of engineering Graduates as identified by the NEEP project in 2010

Qualification type	Actual qualifications completed in 2018	Estimated annual needs "business as usual"	Estimated annual needs "innovation led economy"	% growth required
Level 6 NZ Diploma in Engineering Engineering Technicians – 2 year qualification (Dublin Accord)	270	500	750	85% - 178%
Level 7 Bachelor of Engineering Technology Engineering Technologists 3 year qualification (Sydney Accord)	180	400	600	120% - 233%
Level 8 Bachelor of Engineering Professional Engineers 4 year qualification (Washington Accord)	1050	1100	1400	5% - 33%
Total	1500	2000	2750	33% - 83%

To achieve this aim, the Tertiary Education Commission (TEC) developed a working party known as Engineering Education 2 Employment (EE2E). This group were tasked with increasing the number of students entering engineering. Part of the approach used by this group was looking at Secondary Tertiary Partnerships (STP's) which included a range of different options that would bring secondary schools and tertiary institutions together to promote engineering as a career of choice. One of these options is the 3+2 partnership and

this is the basis of the Integrated Pathways Programme developed between Wintec and both Fairfield College and Fraser High School.

The 3+2 approaches for secondary / tertiary programmes

The purpose of a 3+2 partnership (3 + 2 days) is to offer greater choice of curriculum for learners in the senior secondary school at Level 3, which are aligned to Vocational Pathways. This diversity can provide a range of pathways because of this multi-partnership approach.

While secondary schools have traditionally done well in preparing those school leavers who move on to degree-level study (around 30% of school leavers), they typically do less well in preparing the remaining 70% of school leavers for further study, training and employment (Ministry of Education, 2016). This latter group of young people have diverse needs. 3+2 approaches are primarily aimed at better meeting the curriculum needs of students who have already turned 16 and who have achieved NCEA Level 2. There are also others likely to benefit

Figures published by Education Counts (2017) using Ministry of Education data, identified that for secondary school leavers in 2015 - 2016:

- 19% left school before completing NCEA Level 2
- 27% of learners completed NCEA Level 2 and left without attempting NCEA Level 3
- 53% of learners completed NCEA Level 2 and went on to gain NCEA Level 3
- 32% of students went on to degree level study

This information indicated that there was an opportunity for 3+2 approaches primarily for the 27% of learners with NCEA Level 2 but leave without completing NCEA Level 3, but who might have stayed if the curriculum offering were different. It is also highly likely that this type of programme would appeal to some of the 19% who leave before NCEA Level 2. It may also appeal to some of the 53% of students who progress to achieving NCEA Level 3; after all, only 32% of these go directly to degree level study on leaving school.

What is also really worth mentioning is that some of the 32% that leave to go into degree level study might also find a mix of school and/or tertiary/work appealing – particularly if careful subject selection and programme planning keep the possibility of gaining a University Entrance award alive.

There are significant benefits for learners who enrol in 3 + 2 approaches. It opens up learning opportunities that cannot be delivered at school or at a tertiary organisation and allows learners to achieve NCEA level 3 while working towards a relevant tertiary qualification.

Involvement in a 3 + 2 programme allows students to also experience tertiary learning while still at school while providing an insight into the wide range of careers and jobs available. This type of programme assists learners with an opportunity to plan their pathway to employment and access relevant leaning to get started.

Wintec's Perspective

Wintec has adopted this 3+2 model of learning with two local high school, Fraser High School and Fairfield college to provide benefits to students and secondary schools while also providing a clear and meaningful pathway for student to transition into tertiary study. This approach when applied to engineering means, that Wintec could have some control over the level and types of maths and physics that these students studied, before they transitioned into the NZDE in either Civil, Electrical or Mechanical Engineering. This has been a significant issue in the past and has contributed to disengagement and retention issues with maths at this level.

Fairfield Colleges' Perspective

Fairfield College saw this as an exciting opportunity to connect our students to an engineering pathway that offers significant career prospects. It was a compelling proposition to create purpose and context in learning, with a clearer line of sight between what a student learns at school and how it is connected to an engineering vocational pathway.

As a secondary school, we saw this as a means of retaining students in secondary school education as some of these students would have otherwise left during the year. It provided students with an opportunity to re-engage with science, while giving them a level 3 qualification and a career pathway at the same time. The programme was envisaged to act as a type of springboard for students towards studying at level 5 or level 6 once they left secondary school.

Fairfield College deliberately restricted entry into this programme to year 13 students because we viewed the NCEA Level 3 qualification as the school exit qualification that we were supporting students to achieve rather than a level 2 qualification. We promoted the view that this year was not the final year of secondary school, but the first year of a three-year programme that placed our students in the strongest possible position to pursue tertiary studies with a particular focus towards enrolling at Wintec and studying for the NZ Diploma of Engineering (NZDE). This programme enabled us to strengthen our learning relationship with the tertiary institution and gave our school an opportunity to contribute to an area of national need. The programme was developed to include the following:

- Engineering Science was a requirement. In this the students studied Mathematics and Physics, which was contextualised to Engineering and was developed with the two institutions working together. A lot of the teaching of the Physics and Mathematics concepts were through practical projects.
- Effective Oral and Written Communication was offered as this was needed for any career of our students' choice.
- Healthy Living, was made up of cooking, food and nutrition and physical activity. The reasoning behind including this course of study here was that these are the life skills needed by young adults.
- Developing Career Competencies had a strong focus on career education and soft skills. Students developed their CVs and learnt interview skills with the help of the career navigator programme developed through the Graeme Dingle Foundation and the 'Grow' programme from Deloitte. During some of the sessions in this class engineers were invited into class to give motivational talks to the students to maintain focus and enthusiasm in engineering.

Development of the Integrated programme

To develop this program, it was necessary for teachers from school and Wintec to work closely together to develop a model that would include the different components of the programme mentioned above. To achieve this, regular meetings were arranged between tutors at Wintec and School that allowed the development of a fully integrated 3+2 curriculum - where students would participate in a contextualised program of study for three days at school and 2 days at Wintec. It was important that we developed the school based programme so that it was aligned with the work that students would be engaged in at Wintec. At school, this learning in combination with the fact the students would be out of school for two days, resulted in the decision to set the programme as a stand-alone course that operated independently from the normal school timetable. The objective from the school's point of view was to develop a programme that would deliver engineering competencies, as well as support more holistic growth in the students. An example timetable and summary of content is provided in Table 2 below.

Table 2. The timetable for the Integrated Pathways students in 2016 (Fairfield College).

Period	Monday	Tuesday	Wednesday	Thursday	Friday
1	8.40 (1) Effective Oral and Written Communication	9.00 study class	WINTEC	WINTEC	8.40 (2) Developing Career Competencies
Whanau	9.40 Whanau				9.40 Whanau
2	10.00 (2) Effective Oral and Written Communication	9.50 (6) Engineering Science			10.00 (3) Developing Career Competencies
Lunch 1	11.00	10.45			11.00
3	11.35 (3) Engineering Science	11.20 (1) Healthy Living			11.35 (4) Engineering Science
4	12.35 (4) Engineering Science	12.45 (2) Healthy Living			12.35 (5) Engineering Science
Lunch 2	1.35	1.35			1.35
5	2.10 (5) Healthy Living	2.10 (3) Engineering Science			2.10 (6) Effective Oral and Written Communication
	3.10	3.10			3.10

During the three days at school the students would study Engineering science (Maths and Physics), Communications, Physical Education and Health Science. The Engineering Science component was developed from the NCEA level 2 Achievement standards for Maths and Physics, which were suitable for entry into the NZDE in Engineering at Wintec. Tables 3 and 4 over the page, shows the list of Maths and Physics achievement standards that would be taught in school. With these standards in mind teaching activities were selected that would enable the students to explore engineering concepts from the three engineering disciplines, Civil, Mechanical and Electrical Engineering.

These activities were designed to engage the students with the maths and physics required to support the concept, all the while making sure that the requirements of the Achievement standards were being met. A typical example was the design and build of bridges. This activity included research into different bridge designs which also looked at the maths and physics associated with each design. The students then had to build a bridge to fit a specific criterion and then test them. The students' knowledge of these discipline areas was tested at the end of each term.

To compliment this programme of work the students attended Wintec for 2 days and were enrolled in two Level 3 Trades Academy courses in Mechanical Engineering (Semester 1) and then Building and Construction (Semester 2). These courses were chosen because:

Table 3. Maths Achievement standards being taught at school

Maths Core compulsory must be taught				
Unit	Title	Credits	Level	Exams
91259	Apply trigonometric relationships in solving problems	3	2	Internal
91261	Apply algebraic methods in solving problems	4	2	External
91262	Apply calculus methods in solving problems	5	2	External
Compulsory with less emphasis				
91269	Apply systems of equations in solving problems	2	2	Internal
Optional/ Extended				
91257	Applied graphical methods in solving problems	4	2	Internal

Table 4. Physics Achievement standards being taught at school

Physics Core compulsory must be taught				
		Credits	Level	Exams
91171	Demonstrate understanding of mechanics	6	2	External
91173	Demonstrate understanding of electricity and electromagnetism	6	2	External
91169	Demonstrate understanding of physics relevant to a selected context	3	2	Internal

1. they would complement the teaching at school;
2. they were courses that Wintec already delivered and that the students could access with their current skill levels; and
3. They would be able to achieve NCEA level 3 credits through these Unit standards.

Tables 5 and 6 below show the list of Unit standards that the students studied on this programme. The Achievement standards mentioned in tables 3 & 4 above and the Unit standards in tables 5 & 6 below, refer to discrete pockets of learning around a specific topic. The credit level gives an indication of the amount of work required with one credit equating to 10 hours of study. The standards can be either level 1,2 or 3, and an approved programme of Unit standards can lead to a qualification, while the Achievement standards lead to NCEA level 1, 2 or 3.

This teaching was supported by site visits in a range of different engineering disciplines such as to a visit to Glenbrook Steel Mill to talk about Materials and materials testing, and also a visit to Huntly Power station. Guest lectures were also arranged with engineers coming in to talk about what they did in the real world. A very good example of this was a visit by a young Civil Engineering (Wintec) graduate working with MWH who talked to the students about his background and studies and provided some really interesting examples of the modelling he uses for road design.

Table 5. Mechanical Engineering Unit Standards

Unit Standard	Title	Credit	Level
25075	Perform basic fabrication operations under supervision	12	2
4797	Demonstrate knowledge of the composition of engineering materials	5	3
21910	Interpret mechanical engineering drawings	5	3
10 credits available out of the possible 20 credits listed below			
22908	Demonstrate and apply knowledge of manually controlled machining operations	10	3
2677	TiG Welding	6	3
2683	Thermal cutting	4	3
	Total NZQA Credits	32	

Table 6. Building and Construction Unit Standards

Unit Standard	Title	Credit	Level
12998	Demonstrate knowledge of carpentry hand tools.	4	3
12999	knowledge of timber machining equipment	3	3
13037	Safely use and maintain carpentry hand tools on site.	6	3
13038	Safely use and maintain bench saws	2	3
24378	Perform building calculations.	4	3
24381	Knowledge of floor framing and flooring construction.	3	3
24401	Install thermal insulation materials in buildings on site	1	3
13032	Non-mechanical, Mechanical Construction Equipment	1	3
16407	Use and maintain hand and power tools for electrical work	4	3
	Total NZQA Credits	**28**	

During the running of the program all institutions worked closely together providing ongoing support to ensure that delivery aligned to provide the best possible learning experience for the students. To determine how well this program of study was progressing, a framework of data collection was wrapped around the program. Data was collected via a range of different mechanisms both at school and at Wintec. At school discussions between the students and teachers occurred throughout the week, the information from which was fed into weekly sessions at Wintec. Aligned with this every 6 weeks all tutors would meet to discuss student progress, and to ensure that the students were receiving adequate academic and pastoral support.

As well as the 6 weekly meetings at Wintec data on student progress while at Wintec was gathered using a variety of different mechanisms, including in class feedback, student forum sessions, and assessment marks. As well monthly progress reports were compiled and sent

to schools and parents to keep them informed of the students' progress. This also allowed for intervention strategies as required. As the program drew to its conclusion a survey of the students was also conducted. The aim of this survey was to determine why the students engaged with the program, what they thought they had got out of it and also where they believed it was taking them.

Results

Out of the 15 students enrolled from Fairfield College in 2016, 13 students achieved all or some of the 48 credits available at NCEA level 3 from the Mechanical Engineering and Building and construction courses at Wintec. Out of these students, 9 were eligible to enrol in the Mechanical NZDE. The remaining 4 progressed out into employment.

Feedback provided by the students from the initial survey suggests that they were better prepared for study at tertiary level and were more confident in their understanding of practical and project based approaches to teaching. The students also mentioned that because of their involvement with the Integrated Pathways programme they believed they were more informed of the potential engineering pathways available to them in engineering. They also believed that they could make more informed choices about their future study and career pathways. However, the students also mentioned that they had been influenced in their choice of engineering discipline through their exposure to the practical engineering courses they had studied first in Trades Academy, rather than the site visits and guest speakers. Hence all the students from Fairfield College enrolled into the Mechanical NZDE.

Discussion

From the conversion rate of students into the NZDE this programme could be deemed a success, the disconnected had been connected. However, this is only from one school, this conversion rate did not translate to Fraser High School. A major issue faced by both institutions was the selection of the students for the Integrated Pathways Programme. For Fairfield College, the aim of the programme was to provide an alternative way for some of their students to achieve NCEA level 3. For Fraser High School it was more about providing their students with exposure to engineering career pathways, while many of their students were already enrolled in and were studying towards NCEA level 3. This provided 2 cohorts of very different students coming into Wintec. However, the aim for Wintec was for a cohort of students who would be better prepared and equipped for entry into the NZDE, and as all parties were working towards a common goal it was possible to provide modifications to the programme, generally within the school, that would complement each cohort.

While the idea of the programme worked well in theory, some of the realities of the contexts in which we work provided several significant obstacles, for example issues with funding when moving between secondary and tertiary environments. In NZ, secondary funding is governed by the Ministry of Education (MOE) while tertiary funding is overseen by the Tertiary Education Commission (TEC). Therefore, for funding of the programme, there were significant hoops to jump through which needed to satisfy either one or both funding bodies. Another major issue was time-tabling of activities between the various institutions, this proved to be quite challenging but the constant communication amongst the team enabled the re-arrangement of classes to accommodate most timetable changes and issues.

While we have focussed on some of the issues, there have been a number of unforeseen benefits to all the institutions involved – one of these comes in the form of the learning and professional development that has come from teachers from both schools and ITP moving into each other's environment to teach. This has provided significant benefit in providing linkages for the students between their theory and practice, and in improving teaching practice in both institutions

For the students, a significant learning was how influenced they were by the first Trades Academy programme that they studied. This means that going forward the programme design needs to ensure that the students have equal exposure to the three main engineering disciplines so that they could make a qualified choice on their field of study. As can be seen from the numbers who enrolled into Mechanical Engineering this was not the case for this particular cohort.

Conclusions

Overall this programme has been a success and both schools have moved into a second year of the programme. The partnership has used the learnings from the pilot in 2016 to implement changes and move the programme forward, to enhance the students' experience and learning opportunities within engineering.

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