The role of engineering in a career change pathway into technology teaching

P. John Williams
pj.williams@waikato.ac.nz
University of Waikato, Hamilton, New Zealand

Janis E. Swan
j.swan@waikato.ac.nz
University of Waikato, Hamilton, New Zealand

Beverley Cooper
bcooper@waikato.ac.nz
University of Waikato, Hamilton, New Zealand

Mike Forret
mforret@waikato.ac.nz
University of Waikato, Hamilton, New Zealand

Abstract: *The University of Waikato developed an innovative two-year engineering/ education qualification to attract a group of learners traditionally excluded or disadvantaged in their access to tertiary study and secondary teaching as a career choice. The factors that prompted and supported collaboration between the Faculty of Science and Engineering and the Faculty of Education to develop and deliver a programme that enables industry-trained and qualified learners to gain the engineering qualification required for teaching technology in secondary schools is described. A cross-sequential – patch-up research design was used to collect data from students in both years of the two-year programme to assess the effectiveness of the pathway.*

Introduction

There is a dual relationship between engineering and technology in the context of this project. Firstly, university engineering courses provide the basis for developing the content expertise for technology teacher trainees, and secondly, the technology area of study in schools represents a pathway for students into university engineering courses.

The emphasis of the New Zealand Technology curriculum, introduced in 1995 and revised in 2007, is on developing technological literacy to equip students with the knowledge and skills to make informed choices within society and give them access to technological careers. There are opportunities to build skills in a wide range of domains including design, digital information, digital media, electronics, food, graphics, programming and computer science, resistant materials, and textiles. The curriculum provides opportunities for secondary schools to interact with business and industry, to assist students to understand and adapt to a rapidly changing world, and to take a confident part in shaping the future.

The staffing intent was to draw technology teachers from a range of backgrounds and give them professional support for the breadth of knowledge required to teach the new technology curriculum. However, a chronic shortage of teachers qualified in technological areas led to other teachers being reclassified as technology teachers, which impacted on implementing the new curriculum for Technology. Prior to November 2007, industry-trained individuals could gain entry to one-year graduate diploma teacher education programmes using a degree equivalence system based on trade-related qualifications and work experience however changes to the New Zealand secondary teachers' collective contract agreement eliminated this route. This paper describes a solution to this problem and

aims to identify the institutional, personal, pedagogical and interpersonal factors supporting these career change learners as they transition from industry to teaching.

Literature Review

There has been a move internationally to recruit well-qualified second career people into teaching due to concerns related to the quality, retention and status of teachers (Auguste *et al*., 2010; McKinsey & Company, 2007; Kane & Mallon, 2006; Richardson & Watt, 2005). There is very little research documenting learning pathways of mature career changers through their tertiary experiences and on into the first year of their new career. This type of research is important because people are increasingly likely to change career during their working life. Further tertiary education is known to play a pivotal role in expanding career choice (Santiago *et al*., 2008).

Significant links are developing between Technology curricula and Engineering. In several education jurisdictions, variations on 'Engineering Studies' is included in the technology suite of subjects offered at the senior secondary level (Curriculum Council, 2008; Board of Studies, 2009). In many cases, professional Engineering groups have been involved in designing and developing the curriculum. An example is the contribution from the Institution of Engineers New Zealand (IPENZ) to the New Zealand technology curriculum (IPENZ, 2010). These links have developed partly through the recognition that the technology learning area represents a significant pathway into tertiary Engineering studies and thus enhances tertiary enrolments.

Proposals for integrating Science, Technology, Engineering and Mathematics (STEM) also impact on the links between technology and engineering at the secondary school level. This is particularly pronounced in the US (The White House, 2009) and UK (Barlex, 2007), and to a lesser extent South Africa and Australia. The rationale is generally derived from shifts in workforce patterns and the downward trends in economic indicators (DfES, 2006). The project described in this paper is an additional example of the worthwhile links that can be established between engineering and technology, in this case through teacher education.

Research Context

Background to the New Teacher Training Pathway

The University of Waikato was approached by the Ministry of Education in September 2007 to develop a pathway for industry-qualified people to become secondary school technology teachers. The Faculty of Education and School of Engineering at the University of Waikato collaborated to develop a two-year stair-casing pathway to achieve this goal. The two-year Graduate Diploma Engineering/ Graduate Diploma Teaching pathway enables career changers with industry backgrounds to enhance their engineering qualifications to reach teaching entry level while concurrently completing a secondary teaching qualification. This pathway recognizes industry qualifications and experience and focuses on enhancing pedagogical understanding of the technology curriculum. The pedagogical skills required to teach technology are learnt while concurrently enhancing their content knowledge of technological processes and practices in a multidisciplinary tertiary setting. The School of Engineering takes into account the individual's qualifications and experience when determining entry to the GradDipEng in Technology Teaching. Entry into the GradDipT is determined by the Faculty of Education, who interviews each candidate to assess their disposition to teach.

Working with this cohort presents some challenges due to factors such as varied backgrounds, the history of formal study engagement, and limited mathematical skills required for the higher engineering papers. The Faculty of Education was experienced in working with this type of cohort and confident it could support the students into university study, so the first year of the programme focuses on the GradDipT and the technology curriculum. The second year of the programme involves extending their engineering knowledge learning and more about technology as a discipline. Students attend regular engineering classes and are not identified to staff as being Diploma students. The technology papers and the final teacher education paper of the GradDipT are also completed in the second year.

Three new papers were developed for the GradDipEng course. The first two papers, *Technological Practice* and *Technological Knowledge*, specifically provide opportunities for the cohort to think more deeply about technology and its components. The third paper, *Engineering for Technology*, builds the cohort's knowledge in engineering and is based on a compulsory paper in all programmes of the four-year professional engineering degree offered at the University. This paper involves increasing the candidate's knowledge of the foundations of engineering and includes a team design-build project. The remaining papers in the GradDipEng, which build on the candidate's prior qualification, are selected from mechanical, chemical, electronic, biotechnology, or IT papers in the mainstream engineering programmes.

Aim of the research

The study aims to identify factors that support career change learners including: institutional, personal, pedagogical and interpersonal relationship aspects, and so is guided by the research question:

- What institutional, personal, pedagogical and interpersonal factors support career change learners participation and engagement in tertiary study?

Methodology

A cross-sequential – patch-up research design (Arzi, 1988) was used to collect data from students in the two years of their course (Table 1), which allows a broad understanding of the student's learning pathways during the programme. The learning pathways of career changers are tracked by examining their prior experiences in polytechnics and industry settings and then their transition into tertiary learning in both teacher education and a specialist field. These data will be used to inform development of further programmes within the tertiary sector to effectively support career changers.

Table 1. Data collection

Cohort	**2009** Year 1 teacher education programme	**2010** Year 2 teacher education programme
Data Collection	Two focus group interviews (7 students in each group) Class survey	Three focus group interviews (5 students in each group) Online class survey

Data collection

Year 1 students in 2009 completed a survey toward the end of their first year and were invited to participate in focus group discussions of their expectations, experiences, and the elements that have contributed to their participation and success in the programme. These students participated in further focus groups and completed an e-survey in 2010. The focus groups explored transitions between the workplace and tertiary study (2009 Year 1 cohort), and between the first and second year of tertiary study (2010 Year 2 cohort).

Four students with diverse prior experiences were selected for in-depth interviews to develop learning pathway case studies. The interviews explored industry training and experiences, recruitment and selection, and participation in tertiary study in both teacher education and their specialist subject.

Findings

The following discusses the key findings, derived from the multiple sources of data: surveys, focus groups and in-depth interviews.

Twenty-two students began this course in 2009 and nineteen successfully completed in 2010, one student dropped out and two are continuing and will complete, taking more than two years. Their ages ranged from 37-53 years and they had spent an average of 20 years working in a variety of trade backgrounds encompassing telecommunications, engineering, architecture, cooking, electrical, sheet metal, carpentry, automotive, information technology, textiles, plumbing, design, boatbuilding, telecommunications, building, fitting and machining and brickwork technology. Apart from their trade training, some had studied in other areas including Biblical Studies and Agriculture.

A diversity of experiences was typical of the group. For example, the following case of Sam:

> *Well, for me I'm a boat builder by trade but I spent six years working at the polytech teaching boat building. Prior to that I've been in the army and I've been a scout leader. I spent the first sort of eight years mucking around, just sussing out what I was going to do, and everything just kept coming back to scouts and soldiering. And so when I moved back to New Zealand from Australia I ended up with a polytech job and I got made redundant from that in 2007 and I couldn't work back in industry. So for me it's just a sideways move.*

The students recognized this diversity of background as being useful when teaching Technology. They had learnt that the curriculum had moved on from its historical focus on mainly manipulative skills development, but there were qualities that a successful tradesman had that were useful: '*you do find that if you're a metal worker, a bricklayer or whatever, you've got that touchy-feely kinaesthetic sort of thing that you can work with your hands and you know how to make things happen'*.

Most of students acknowledged they would not have been able to complete the two-year course if they had not been successful in gaining a scholarship, as most had families to support. One non-scholarship student sold his house to meet his costs during the period of study. Most students were self employed prior to beginning the course, and some were working in schools but were not employed as fully qualified teachers.

During the focus groups, the trainee teachers spent a significant amount of time discussing how the various elements of the course fit together to meet their perceived need in preparing them for the technology classroom. One of the overarching issues was the course structure in which the Educational qualification was completed in the first year and the Engineering qualification in the second year. In a general sense, Education focussed on pedagogy and curriculum and periods of practice in schools, and Engineering focussed on content. The trainees perceived this as problematic for two reasons. The first is that by the time they have completed their qualifications, it is over a year since they have had any school experience. Secondly, they felt it would have been easier to do the content first and then learnt how to apply that to the classroom through the Education qualification and school practicum experiences. There was some recognition, however, that it was important to validate the decision to become a teacher early in the course by engaging with school experiences. People could then opt out if they felt they were not suitable.

In the focus group discussion, the trainee teachers emphasized the importance of social groups as they progressed through the course. '*We had a really good study group and we stuck together for two years which was very good support'*. The surveys they completed indicated that 'group or team-based activities' was the classroom strategy they enjoyed the most, although lecturers and tutors were most helpful in developing understandings about what they were studying.

The average age of this group was 45, and this was a social factor in some instances. One student felt quite isolated in an elective engineering class he took because he was a good 20 years older than anyone else in the class. In other classes where the lecturer formed the groups, having a mix of younger and older students in each group was felt to be a positive feature, '*but it does get very frustrating working with young people that don't understand the importance of working to deadlines and planning and those kinds of issues'*.

Working in classes beside younger students who were just out of school was seen as an advantage for developing a deeper understanding about the characteristics of this age group, which could be subsequently applied to their role as a teacher in schools. '*I think at the end of it, the big picture is that people get a lot more out of it in terms of learning to work with young people'*.

The initial expectations of the students with trade backgrounds was that they were training to be teachers so they could teach to school students the skills they had developed in their trade. When initially confronted with the Technology curriculum, they wondered '…*what the hell is this about?* But they persevered and at some stage in the course *'the penny dropped and you suddenly realized about technology, and we all started discussing technology in a completely different way over cups of coffee'*.

They perceived this new curricular perspective as very positive: a '*coming out of the apprenticeship closet'* as one student described it. They could see that the problem solving and critical thinking skills that accompanied design work in a practical context as developing '*a bigger, rounder kid than you could produce without technology'*. This evolving understanding was a product of technology curriculum papers that were scaffolded across both years of the course, and designed to progressively develop deeper understandings of the nature of technology.

When the students developed an understanding of the Technology curriculum, and were then in their second year studying in the School of Engineering, they could see a clear pathway between the two – school Technology and university Engineering. This led them to believe that many in the Engineering faculty did not understand the contribution that technology could make for students coming into an Engineering course at university. They also recognised that prerequisites in Mathematics and Science could be very usefully complemented with studies in Technology but that high schools often 'stream' students into either Math/Science or a Technology, based on academic ability.

This important link between school Technology and university Engineering is recognized in some jurisdictions, particularly those where the STEM (Science, Technology, Engineering, Mathematics) agenda is gathering momentum such as the USA and the UK. President Obama's announcement of STEM initiatives (The White House, 2009) and the appointment of a STEM Director by the UK government indicate the significance of the developing relationships between Technology and Engineering.

The students noticed some dissonance in the student centred and collaborative pedagogies they were being taught to use in schools, and the teaching styles of some of the university lecturers, which were '*a lot of sort of chalk and talk'*. The focus when delivering the Technology curriculum in schools is on activities that engage students and encourage development of creativity and a range of higher order thinking skills. This was contrasted with university lecturers who are generally content experts with little pedagogical training, and consequently assume learning is an inevitable outcome of teaching, regardless of how teacher-centred it is. This is despite engineering graduate competency profiles including attributes such as analysis and problem solving, and design and synthesis of complex problems (IPENZ, 2009).

At the conclusion of one of the focus group interviews, a request was made for any final comments. The singular final comment was '*thank god it's over',* reflecting not so much the difficulties of studying, but the anticipation of beginning a teaching career.

Conclusions

The school Technology curriculum, which is designed to increase the technological literacy of young learners, needs qualified teachers knowledgeable in both the pedagogy and the content of teaching technology. There is a shortage in New Zealand of teachers who satisfy these criteria. In this project, two faculties (Education and Engineering) collaborated to develop a career-change pathway to produce teachers who would satisfy this need. It involved one year of teacher training and a further year of up-skilling the candidate's engineering skills through a structure of two Graduate Diplomas.

The project investigated the institutional, personal, pedagogical and interpersonal factors that support career change learners participation and engagement in tertiary study. The students interviewed identified many factors crucial in helping them progress through tertiary study. Providing structured opportunities to facilitate supportive learning communities, for both social and academic reasons, during their study was revealed to be significant. There is also a clear need for scholarships to accompany this type of programme to enable and support experienced people from engineering areas to bring skills into teaching. Without scholarships, mature people with families to support are unlikely or indeed unable to

voluntarily forgo two years of income.

The pathway developed by the University of Waikato provided the opportunity for the trainees to engage in engineering learning alongside younger school leavers, which allowed them to observe and experience the links between engineering and school, and consequently encourage them to become "champions of engineering" within a school context once they graduate. It also allowed development of a practical understanding of the characteristics of students in their initial years at university prior to the trainees beginning their careers as technology teachers.

The flexibility and responsiveness of the diploma pathway allowed structural changes in the programme to accommodate student concerns. For example, the timing for the school experience practicums has been changed so students can continue their in-school experiences into their second year.

Early indications are that the combined education training / engineering up-skilling pathway achieved the purpose of changing the teacher trainees' understanding of technology and engineering from a focus on manual skill development to a focus on the design-based problem-solving process. However, the researchers see the need to continue this longitudinal research to determine whether the study pathway has provided for enduring skill development that enables people originally trained in a manual skills focussed system to successfully make the transition to teaching a higher order level of technology and engineering.

References

Arzi, H.J. (1988). From short- to long-term: Studying science education longitudinally. *Studies in Science Education, 15*, 17-53.

Auguste, B., Kihn, P. & Miller, M. (2010). *Closing the talent gap: Attracting and retaining top-third graduates to careers in teaching. An international and market research-based perspective.* New York, NY. Accessed at http://www.mckinsey.com/App_Media/Reports/SSO/closing_the_talent_gap_september_2010.pdf on 17 Mar 2011.

Barlex, D. (2007). 'STEM: An important acronym'. *D&T News* (36). Warwickshire, UK: The Design and Technology Association.

Board of Studies (2009). *Engineering studies*. Accessed at http://www.boardofstudies.nsw.edu.au/syllabus_hsc/ engineering-studies.html on 12 June 2011.

Curriculum Council (2008). *Engineering studies*. Accessed at http://curriculum.wa.edu.au/ internet/Senior_ Secondary/Courses/WACE_Courses/Engineering_Studies on 12 June 2011.

DfES. (2006). *STEM report*. London, UK: Department for Education and Skills.

IPENZ (2009). *Graduate competency profiles*. Accessed at http://www.ipenz.org.nz/ipenz/Education_Career/ accreditation/Graduate_Competency_Profiles_Nov_2009.pdf on 29 Sep 2011.

IPENZ (2010). *National engineering education plan (NEEP).* Accessed at http://www.ipenz.org.nz/ipenz/ education_career/neep.cfm on 20 June 2011.

Kane, R.G. & Mallon, M. (2006). *Perceptions of teachers and teaching*. Wellington: Ministry of Education and New Zealand Teachers' Council.

McKinsey & Company. (2007). *How the world's best-performing school systems come out on top*. New York, NY. Accessed at http://www.mckinsey.com/clientservice/social_sector/our_practices/education/ knowledge_ highlights/best_performing_school.aspx on 3 Mar 2011.

Richardson, P.W. & Watt, H.M.G. (2005). 'I've decided to become a teacher': Influences on career change. *Teaching and Teacher Education*, *21*(5), 475–489.

Santiago, P., Tremblay, K., Basri, E. & Arnal, E. (2008). *Tertiary education for the knowledge society: OECD thematic review of tertiary education: synthesis report.* Paris: Organization for Economic Co-operation and Development.

The White House (2009) *President Obama launches "Educate to Innovate" campaign for excellence in science, technology, engineering & math (STEM) education*. Accessed at http://www.whitehouse.gov/the-press-office/ president-obama-launches-educate-innovate-campaign-excellence-science-technology-en on 27 Jan 2011.