Microtechnology and other 'must have' technologies

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Abstract
The aim of this paper is to highlight the major issues that arose during a project demonstrating Vocational Education and Training (VET) organisations working with Co-operative Research Centres (CRCs). Swinburne University of Technology (TAFE Division) was funded by the Australian National Training Authority (ANTA) in 2004 to carry out the project. The demonstration project was underpinned by the concept of skill ecosystems. These are interdependent clusters of high, low and intermediate-level skills that are shaped by a number of factors. The project demonstrated knowledge building as a result of various activities and outlined a number of models of VET and CRC interaction. It was demonstrated that interaction between VET and CRCs benefits both types of organisation but there are still significant challenges ahead.

Introduction

Background

Swinburne University of Technology (TAFE Division) was funded by the Australian National Training Authority (ANTA) in 2004 to carry out a project demonstrating ways in which the vocational education and training sector (VET) could work with Co-operative Research Centres (CRCs). The project was managed by NSW Department of Education. Project participants (the stakeholders) were staff from the MiniFab, Swinburne TAFE Centre for New Manufacturing and the departments of Industrial Science, Mechanical and Automotive; Electrical and Electronics and the Business Enterprise Centre. The project was co-ordinated through the TAFE Division Strategic Planning Services Unit.

CRCs are research and development organisations administered by the Federal Government Department of Education Science and Technology (DEST). There were 70 CRCs at the time of writing this report.

> The CRC Programme was established in 1990 to improve the effectiveness of Australia's research and development effort. It links researchers with industry to focus R&D efforts on progress towards utilisation and commercialisation. The close interaction between researchers and the users of research is a key feature of the programme. (DEST, 2004)

Specialist Centres in the Victorian VET sector are an outcome of State Government policy for vocational education (Kosky 2002). One such centre is the Centre for New Manufacturing located at Swinburne. It works strategically with government, industries, universities, key research centres and the VET sector to identify knowledge and skills required for existing and emerging technologies. It develops new training and works across all departments involved with manufacturing.

The demonstration project was not strictly conceived of as research, but as so few interactions had taken place between TAFE and CRCs each interaction was in the nature of action research.

The Project

The aim of this paper is to assess the major issues facing VET organisations working with CRCs that arose during the demonstration project. Strategic Planning Services had carried out a preliminary project scoping the current and potential linkages between Swinburne's CRCs and its TAFE and Higher Education Sectors, which paved the way for further interactions. (Firminger 2003).

The CRC/VET demonstration project was underpinned by the concept of skill ecosystems. These are "interdependent clusters of high, low and intermediate-level skills that are shaped by the business environment; that is, how firms are organised, competition, the financial system and markets for products; as well as policy frameworks, the structure of work and the level and type of skill formation." (Anonymous, 2002)

Microtechnology is an example of a technology that is seen as one that must develop a skill eco system of high and medium level skills.

> *Australian industry … opted out of the microelectronics revolution. Since each new industry is generally based upon a sound foundation in the previous ones, the almost complete lack of industrial investment in cleanrooms, wafer processing equipment, deposition gear and the like has resulted in a serious lack of trained technical officers, poor service and maintenance infrastructure, and weakly developed design skills."* (Harvey & Murray 2002).

If the VET sector fails to provide the necessary training to support the uptake of microtechnology through workforce capacity building, the chances of business success will be diminished. VET training in new technologies must be multi-disciplinary because convergent industries 'demand' this.

Buchanan *et al* have researched skills shortages in the manufacturing trades. Policies developed to address the supply of skills were based on the British model but research has shown British apprentices were narrowly trained as a result of high demarcation barriers. By contrast German apprentices were broadly trained and German industry flourished. Following these results Australian policy centred on flexibility; reducing demarcation issues and government agencies attuning policies to business needs. The acquisition of skills became a public policy issue. (Buchanan *et al* 2001). This policy does not, however appear to deal with the convergence of skill sets discussed below.

In engineering, competition has changed due to the reduction of tariff barriers and due to excess manufacturing capacity world-wide. This has lead firms to compete on the basis of cost partly to reduce demarcations and narrow job definitions, partly to reduce spending on training; and partly to increase the use of labour hire firm's flexible labour supply. This has led to low skills equilibrium systems, although as noted, these 'equilibriums' are still under constant threat from new technologies and from international competition. (Buchanan, *et al,* 2001)

If the manufacturing industry does embrace new technologies this will entail re-skilling some workers. Current apprenticeship and diploma training is still narrowly focused within industry-specific disciplines, but microtechnology and other new technologies converge several industry disciplines. For TAFE in particular, overcoming skills silos

is critical. Specialist Centres are one means to achieve this as they can knit together training from different discipline areas.

Method

The objectives ANTA set for the project were to demonstrate how VET providers can collaborate with CRCs to increase innovation in firms and networks of firms and assist in the process of commercialising and diffusing innovation.

Swinburne's previous research had identified potential synergies between the MiniFab, the Centre for New Manufacturing and the emerging skills research being carried out by Strategic Planning Services. Teacher training in emerging skills had separately been identified as a priority area and it was though TAFE student exposure to new industry would also be an appropriate subject to demonstrate. The CEO of the MiniFab identified a need for PhD students to gain insights into small business management and the possibility of the MiniFab sharing TAFE resources as two issues for the project to investigate. This formed the core of the project. In addition the project investigated different models for TAFE to work with CRCs or similar bodies; and tracked two bids for new CRCs that had Swinburne TAFE involvement. The latter is not discussed in this paper.

In summary, the parts of the work referred to in this paper demonstrate:

- The process of knowledge building as a result of industry release for teachers
- The effects of student projects conducted in a research facility
- The sharing of resources between TAFE and higher education or research facilities
- The basic training would be useful to PhD graduates setting up a business?
- Other models of VET and CRC interaction.

Findings and Discussion

Industry release for teachers at the MiniFab

Initially, three teachers from the Swinburne TAFE Division spent a week on industrial release at the MiniFAB to understand the new knowledge embedded in microtechnology. They were from the Mechanical & Automotive Technology, Industrial Sciences & Electrical & Electronics Departments. Later two further teachers were released to the MiniFAB indicating that the partnership was growing and ongoing. Their brief was "to analyse the research and work done by people at the MiniFAB, identify relevant skills associated with the technologies under development and map these against existing technician-level courses." The teachers then participated in the development of a program/seminar for TAFE teachers on technologies emerging in the research laboratories at the MiniFAB. Following their industrial release, the teachers reported back to directors, managers and teachers at Swinburne; then through seminars, to teachers and business people from other organisations.

The industry release was unusual and challenging in that it involved teachers from three teaching departments in two TAFE schools. One of the teachers commented on how necessary it will be for teachers to be multiskilled across disciplines in the future, as is happening now with mechatronics. However he indicated that it was difficult to do this in the trade areas. "There are real industrial issues if you try to cross disciplines, but once you get to post-trade courses these are people who will be designers or managers so industrial issues are not a problem". Another teacher expressed some frustration that his work at the MiniFAB was not of immediate relevance to his teaching practice. He

was weaving some of it into his content delivery, especially in application digital signal processing, however this was not in the course content, and the students were not required to show competence in microelectronics at the end of the course. He felt the learning was too far ahead of today's teaching to be of practical use in TAFE as his students were unlikely to work in microelectronics.

The teachers grappled with the relevance of their research laboratory experience to their current teaching. This is hardly surprising, as a research laboratory is producing prototypes that are yet to be commercialised, while VET teachers train people in current skills for existing technologies. However, the issue of timeliness is crucial in the transfer of knowledge from a research setting to an industrial setting. VET teaching takes place within the framework of the current training packages developed to meet industries current skill needs and is not concerned with future skill needs. We need to find better ways to link the conceptual or knowledge work done in a high-level research organisation to the potential training outcomes in VET.

Another interesting finding from the demonstration project was that the learning experience and benefits were two-way, especially in the prototyping phase of research. When PhD students move from producing a single device to producing many, they lack the industrial skills needed to streamline production-phase procedures. TAFE teachers have these skills, and can play an important future role in the commercialisation process. One of the teachers felt that TAFE teachers are well placed to teach these skills. He felt that when these students obtain a new piece of equipment they 'grab' a small amount of vendor training but not enough to use the equipment skilfully. As a result, some industrial practices were "very ordinary"; needing a better process orientation, and more practical training. Another instance of two-way benefit was the MiniFAB request for a DNA expert from TAFE Industrial Sciences to analyse the 'stickiness' of DNA to different sorts of polymers, and he accessed more up-to-date equipment from the TAFE Division to do this.

Overall the industry release was a very positive experience. The teachers were made to feel welcome at the MiniFab. The teachers were chosen because they were curious about future technologies and willing to try something different. Their positive experiences helped less flexible teachers move forward. The willingness of teachers to embrace new technologies or processes is one of the most significant issues in VET/CRC interactions.

Student projects at the MiniFab

Students from Mechanical & Automotive, Industrial Sciences and Electrical & Electronics were chosen to undertake projects by the teachers who had done industry release. Staff at the MiniFab put considerable effort into devising three projects they thought would interest TAFE students. Unfortunately the Electronics project did not go ahead because at present there is no project-based teaching undertaken in that department.

Two second-year Diploma students from Industrial Sciences undertook a project to develop a workflow template for an ongoing commercial project utilizing the MiniFab cleanroom. The aim was to introduce industrial practices to track the development of the product from start to finish. Their teacher was very supportive of their project.

The two students were unable to relate their experience to their study. They called their project 'analysing workplace communication'. Most of the analysis took place sitting at a desk using a computer. This was frustrating for them and the least enjoyable aspect of the placement. One of the students found it interesting to examine the processes of a research environment but felt it was irrelevant to her career goal of teaching science. The same student felt such a placement would be relevant to people wishing to "incorporate engineering into their course."

The second student wanted to work in a medical science laboratory and undertook the placement because he thought it related to biotechnology. He felt the environment was an "engineering laboratory rather than a biotechnology laboratory." He found the "office work" challenging as "I was not used to doing desk work all day. (There was) not enough practical work." He was not interested in becoming a biochemical engineer and would "rather use technology than design technology". He found the experience of working in the MiniFAB unusual – people were all working on separate tasks autonomously. Interaction between students occurred only when necessary. He thought this type of placement would suit engineering or biochemical engineering students or those students interested in designing small devices.

Two students from Mechanical and Automotive undertook a project to develop for possible manufacture a standardised microfluidic 'breadboard' to be used by research students. They completed that project and then engaged in developing the syringe pump for the 'breadboard'. The first was a mature age student who had worked in several industries before deciding to study automotive design. It added value to his studies by introducing him to new materials and to practical demonstrations of knowledge. The most challenging aspect of the project was the project management process. At TAFE, teachers often prepare assessment tasks for each stage of the project, at the MiniFAB they had to design and implement their own project.

The second student came directly to TAFE from secondary school and was studying the Advanced Diploma of Robotics and Mechatronics. His course was mostly computer-based designing so he found the mechanical aspects of the project very challenging. His view was "we study known things and learn to utilise them in industry, we don't do research." The other challenge was his lack of project management skills. The projects undertaken in his course were closely guided by teachers who control the amount of work, set finish dates and decide who does the tasks. He felt he needed more preparation.

All the students commented on how welcome they were made to feel at the MiniFab. The teachers commented that the timing of the two weeks was difficult and it could be difficult to schedule similar projects in future. The MiniFab supervisor felt he needed better briefings including an outline of the course work the students had completed, so the MiniFAB could see what information the students were already familiar with.

Student involvement with CRC projects is problematic firstly because departmental silos exist at the student level too. This adds to the difficulty of integrating training for convergent industries. The project assessment needs to be mapped against a number of competencies, elements and performance criteria so that assessment is valid. Secondly, it is difficult to tailor a project to the knowledge level the student has before they complete their course. Thirdly, teachers briefing students in research areas need to be

clear on what is expected of the students, and research or higher education personnel need to be aware of the TAFE student's level of understanding. This is no easy task and cannot be expected to work smoothly until there is a greater understanding of new technologies by teachers. Fourthly, it appears project management skills in some TAFE courses at present do not sufficiently prepare students to manage projects in low supervision environments.

Resource sharing
Generally a TAFE institute of division is better resourced with equipment and technicians than CRCs. The MiniFab lacked basic equipment such as soldering irons and its students lacked skills in the use of these. Because of this need a resource sharing trial was organised between the MiniFAB and the various TAFE departments. Resources were broadly defined to include tools, equipment, knowledge and expertise. Possible legal issues were discussed with the Legal Department and there was no impediment to going ahead.

A set of protocols for sharing resources was devised and agreed to by all parties. Resources were to include sharing of equipment and expertise, including cash transfers, and the possibility of using students as a resource.

Sharing was found to be a two-way experience. For example the Electrical & Electronics department shared their CISCO laboratory with higher education students. On the other hand, a TAFE Division teacher organised a visit to the Photonics laboratory in the Higher Education Division for TAFE students completing the photonics module of an electronics course to enhance their learning experience. This has proven to be a low-key method of developing relationships and mutual understanding.

Business awareness training for research students
A number of PhD research students at the MiniFAB expressed interest in starting small businesses to develop micro products they researched and developed to the prototyping stage. However, most lacked an understanding of small business basics.

Swinburne TAFE is home to a Business Enterprise Centre (BEC). Its role is to assist start-up businesses with basic competencies in running a small business. The BEC agreed to participate in the demonstration project and work with the PhD students. The trainer had experience running introductory business courses in technology industries in the Philippines and experience in his own business. The course was customised for this group of students.

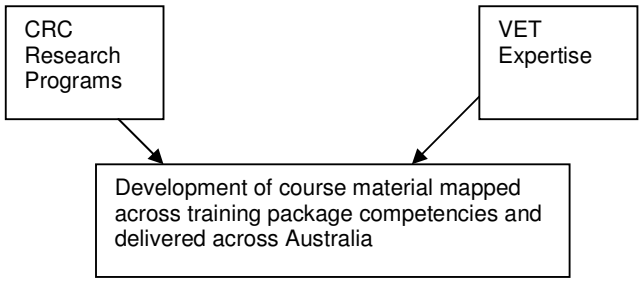
The overall assessment by students was positive; the best aspects of the course were the presenters experience and the examples of how businesses operate. Improvement was needed in the speed at which the material was delivered, the students found it too slow and somewhat repetitive. Business awareness and requirements were the most useful sections of the training. Small business management skills would be relevant for students in CRCs where spin-off companies are an expected outcome.

Models for VET and CRC interaction
VET providers that wish to link with CRCs or other high-level research organisations need to examine their own expertise first, in particular the teaching expertise, industry

linkages and resources that might be attractive to a CRC. The next step is to gain support from senior management, department managers and teachers willing to try something new. A significant investment in time is needed to establish relationships. The CRC website carries a lot of information about research themes and projects; as well as a list of partners and key personnel. Annual reports list research and development achievements. A preliminary contact with the CRC education officer would be a low-key introduction. Be prepared for the fact that, for many CRCs, the main roles of 'education' is to recruit students for PhD projects and to disseminate research findings through papers, seminars and so on. There is often no understanding of the VET sector and any possible relevance it may have to research.

A number of different types of VET/CRC interaction are outlined below. They demonstrate that there is no one formula for VET to link with CRCs

Figure 1: Model One – the ideal path from knowledge to training



The 'ideal' path indicated in Figure 1 is possible but may be rare. Model demonstrates the path taken by the CRC for Cast Metal Manufacturing (CAST). It developed a training model in conjunction with Swinburne TAFE staff to determine the curriculum needs and associated costs for a course to train people to be job-ready for working in a smelter. This is an industry with very thin training markets and the course was envisioned as being part of an integrated training program stretching from secondary school to PhDs.

The CRC for Australian Weed Management also fits model one. It attempted to establish links with VET providers to use the R&D it developed, but did not have the time to make approaches to every Institute. CRC staff were unable to penetrate far enough into the system to discover the existence of the NSW DET which would have facilitated such linkages. However when the CRC became aware of national competencies, and when, at about the same time, a local VET organisation made contact with the CRC seeking information on weeds management, the CRC developed a renewed focus on VET which led to the development of teaching resources, and the employment of an education officer with a focus on VET. The CRC has mapped their online resources across competencies in the Conservation and Land Management Training Package and made these available to all providers delivering this course.

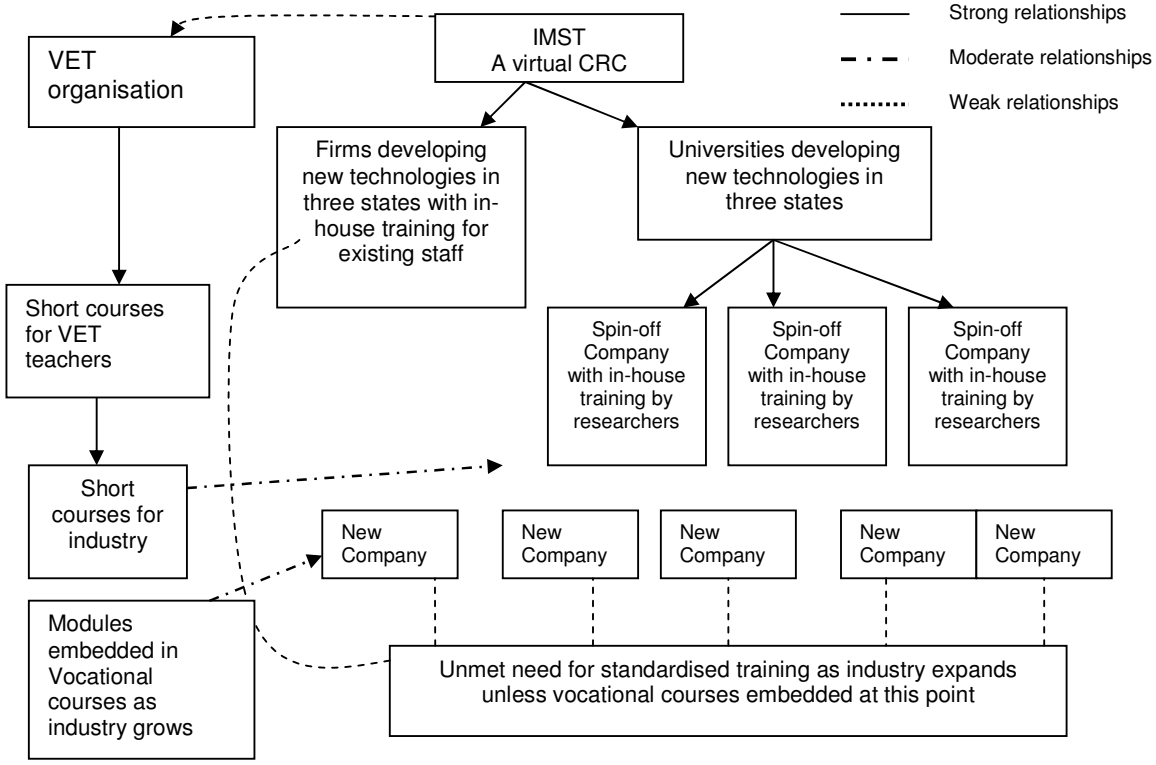
Swinburne attempted to link with the CRC for Asthma as it appeared to be "a good match" to Swinburne. In some respects it too is an example of model one. The CRC operated some of its programs in Victoria and had relevance to the teaching areas of childcare, aged care, division two nursing, and recreation courses. All of these courses contain an element of asthma management training.

It was a difficult and time-consuming task to make contact with the CRC and made even more difficult by the absence overseas of the project leader for the Asthma management program. After some time the CRC suggested Swinburne contact Asthma Victoria. It is a small non-profit VET organisation delivering a number of different short courses in asthma management, to a wide range of health care workers and has been involved with the CRC since the initial bidding process began. Its involvement has been very proactive, with input into the shape of the research programs and a large survey of asthma patients in hospital, which informed some CRC research. Asthma Victoria also organises forums for CRC staff to talk to health professionals about their findings.

Swinburne also has a strength in emergency services training and briefly investigated the possibility of working with the Bushfire CRC. The CRC has very strong links with an industry association, the Australasian Fire Authorities Council (AFAC). All fire agencies in Australia are members of the council. Should new training be needed, AFAC will develop this to be delivered through its VET members – a slight variation on model one. The Asthma and Bushfire examples demonstrate that small specialised RTOs can play a significant role in a relationship with a CRC. However the amount of time this demonstration project took to ascertain the linkages in the Asthma CRC serves as an object lesson in the difficulties of establishing VET /CRC links.

Some CRCs are very complex organisations. The CRC for Intelligent Manufacturing Systems and Technologies (IMST) is a case in point; it is a virtual CRC as shown in Figure 2.

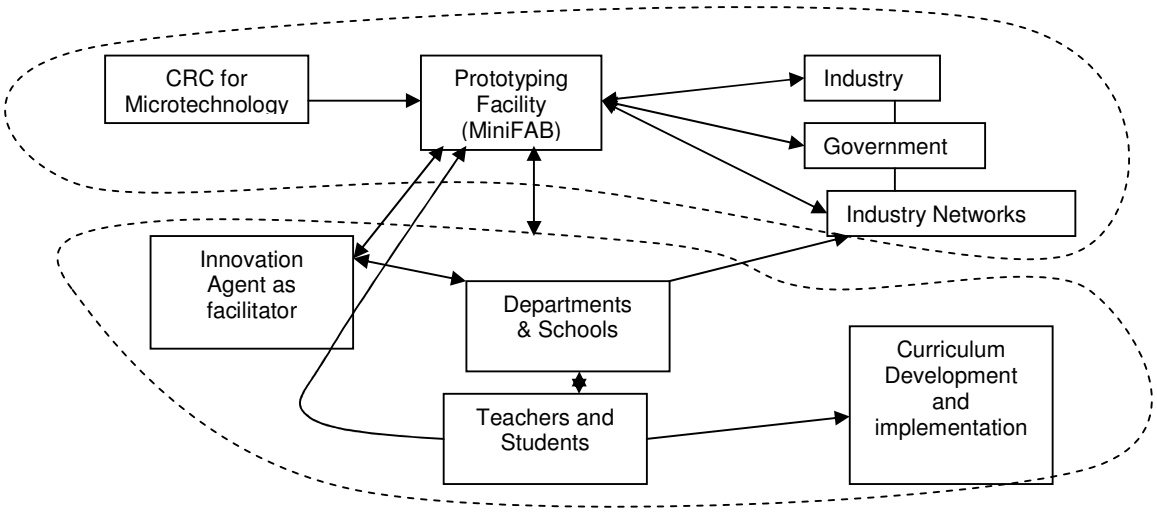
Figure 2: Model two – the virtual CRC



The CRC has a number of large enterprises and a number of universities as partners, all spread across three states. It has no 'home' where devices or processes are prototyped. The intellectual property (IP) is developed in the large firms and universities. The IP developed in the firms remains in those firms and should technician training be needed, it is carried out by in-house trainers who translate the knowledge into training. Small companies are spun-off from university research with the involvement of the researchers. They too do their own training. In this model, if the industry becomes larger, that is if the particular technology becomes standard in many firms, not just those associated with the CRC, there is no standardised training available. If a VET organisation is able to develop an early relationship with the CRC, there is a better chance of training being available when it is needed by larger numbers of firms. Many CRCs have complex relationships with many partners across a number of states, so some variation on model two seems likely.

In contrast to the above, the CRC for Microtechnology does have a 'home' for its prototyping, the MiniFab and VET /CRC interactions took place through the MiniFab as demonstrated in Figure 3. Before the project that preceded the demonstration project began there was no interaction between the TAFE sector and the MiniFab, they operated as two separate systems (demonstrated by the dashed lines). The project acted as an innovation agent to connect the two systems.

Figure 3: Model three – the CRC with a prototyping facility



The demonstration project did not attempt to articulate further possible models in the 70 CRCs, it is probable that there are more than three models, however these three serve to demonstrate the need to understand how each CRC functions in order to best work with them.

Conclusion

The project demonstrated that there are a number of issues that can inhibit VET/CRC interaction but once these are overcome there are significant benefits from such interactions. For example, industry release is a powerful method for introducing new skills into training but considerable effort has to go into choosing the change leaders and then to bringing other teachers on board. Both resource sharing and offering TAFE courses to higher education students are useful in building relationships. VET student

involvement in research is a complex issue that needs careful planning and management if it is to be of value to those involved.

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