Mega project education and training collaboration

Ross Digby

Victorian Skills Authority Fellowship, 2025

International Specialised Skills Institute

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02
Executive Summary

The delivery of major infrastructure under Victoria's big build strategy is seeing the delivery of mega infrastructure projects. Each of these projects have specific skill needs not only for the project, but for different phases of the project. To deliver the training for mega projects, the training provider should work with the lead contractor or joint venture to understand training needs and provide training as needed. This report examines approaches undertaken in different countries taken to provide accredited and bespoke training for major infrastructure projects. The Fellow has identified factors that can impact on the ability of a training provider to provide training to mega projects, including:

- Effective collaboration between industry and education and training providers
- Preferred workforce development models
- A cost of construction and/or investment in workforce capability
- Project need for accredited training
- Ability of training provider/s to access specialist skills/equipment required for training delivery
- Point of engagement in the project

Observations made and discussions held with education & training providers, industry and original equipment manufacturers (OEM) identified actions that could be undertaken to mitigate barriers to the successful completion of a project. A consistent theme across each of the mitigation strategies was the need for effective collaboration. Not only between the contractor and training provider, but also with statutory authorities, OEM, regulators and government. Critically, when a training provider is involved in the project planning phase, it is likely that the education and training delivered will meet project needs as required for all stages of the mega project.

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Fellowship Background

The purpose of this fellowship is to investigate and understand how education and training providers can effectively collaborate to educate and train workers through all phases in the construction of mega projects. The Fellow's involvement in the provision of education and training for these mega projects has required a rethink as to how education and training can be provided to these projects. Some training providers have struggled to respond to the education and training needs of mega projects, due to:

- Ineffective collaboration.
- A lack of a business-to-business focus.
- Inability to respond to specialist training needs.
- Inability to shift the training profile to reflect the stages of the project

This report has a focus on the priority area of developing quality training with deep and meaningful connections to emerging or ongoing industry needs.

The Fellow's role at the Victorian Tunnelling Centre (VTC) requires clear strategic direction and operational objectives to meet industry needs and be financially viable. The VTC is a specialist training centre. The centre needs to ensure that it provides best practice education and training for the construction and operation of tunnels and underground spaces. The report will make suggestions as to how education and training can be delivered for mega projects in a sustainable and cost-effective way.

Figure 1. Segment lined tunnel under construction for the Guangzhou to Zhaoqing high speed railway, Guangdong, China.

Advances in technologies and techniques to construct major infrastructure, education and training needs have progressed well beyond skilling workers to operate plant, and equipment by hand alone. Skills required on major infrastructure projects demand that workers have the capability to operate and monitor complex plant and equipment to excavate, prepare, lift and connect structures. This is increasingly being

undertaken by computers and artificial intelligence. This requires the operator to now monitor data and information and then decide what adjustments need to be made in the machine's operation. As an educator, to achieve this, training needs to shift from a focus on training individuals to physically undertake a task, to developing the capability and understanding to adjust operations when using robotics or automation. The effective utilisation of digital/robotic and mechanical technologies is inevitable as they can increase productivity and eliminate hazards that place workers at risk of injury or death. The potential for injury or death in the construction of tunnels and underground spaces is high and hazards need to be eliminated.

To ensure that education and training providers deliver training to meet current and future needs. education and training providers need to have ongoing engagement with contractors and OEM. Contractors building mega projects have an international footprint and use plant/equipment designed for a specific purpose and conditions. This requires workers and tradespeople to upskill and reskill to be competent to operate these devices. To deliver this training, the education and training provider needs to have the connection and engagement with those organisations & industry associations to access and understand the training needs of each mega project and have the capability to deliver "digitally focused" education and training. The fellowship provided the Fellow with the opportunity to gain an understanding of effective education and training methods utilised across a range of different education and training systems around the world.

Tunnels and underground spaces will increasingly play a role to assist society to combat the impacts of climate change and increasing population density. Many of the skills used to construct these spaces adapt and utilise existing skills and knowledge used in above ground construction. As society adapts to using these spaces, education and training providers need adapt sustainable education and training practices that minimise re-training. The focus needs to be on adapting the existing skills and knowledge of workers to new technologies, new process and new work environments.

Across Australia over the past 10 years there has been a flurry of activity in tunnel and underground space construction. Technological innovations make tunnelling faster, safer and more cost effective as a means of construction. The utilisation of tunnels and underground spaces for uses beyond transportation and utilities increase. To support this, there is a need to have a workforce who can construct and operate these spaces safely, efficiently, and sustainably. The challenges associated with the provision of this training are substantial, If those working on the project are not adequately trained, there is a high likelihood that the project will not be delivered on schedule or to specification (Damayanti, Hartono et al. 2021, Derakhshanfar, Ochoa et al. 2021). The training required is linked to the skill needs of the project at a point in time, and the training site/s are dependent on the project location.

The training for megaprojects differs from the training provided to service a factory, hospital, or hotel in a fixed location. A mega project workforce is formed only to deliver the project. Once the project is delivered the workforce is dismantled, and workers move onto other projects. Training needs for place-based businesses are relatively fixed and remain in place for the life of the operation. The training required is dependent on project need. It changes at each stage of the project. Most of the training provided is to update workers on new equipment and technologies. How this training is sourced is dependent on the preferred approach of the lead contractor/s often shaped by previous training approaches and experiences. The approach may be influenced by government-imposed skill development targets, particularly if there are financial penalties or incentives linked to training targets.

Ninety percent of lead contractors who have delivered or are delivering mega-projects in Australia are foreign owned multi-nationals whose head office is located outside of Australia. The stance of these companies in the provision of workforce training and development can be influenced by their experiences and workforce development policies in the country in which the head office is located, be that Asia, Europe, or the Americas. The understanding at the executive level that these organisations have of the Australian

VET system may be limited or non-existent. Rather it can be shaped by an understanding of the classical model underpinning vocational education in the country in which the multi-national company is located (Greinert 2004).

To gain a deeper understanding of these vocational education models and their influence on the training delivered to mega project and gain further insights the Fellow undertook visits to several countries. The Fellow also networked with equipment manufacturers, education providers, industry associations and international tunnelling experts as summarised in Table 1. This table outlines the visits undertaken by the Fellow, including the organisation type and the purpose of the visit. The fellowship enabled the Fellow to undertake visits to several countries to gain an understanding as to how vocational training has been structured to meet the workforce development needs of mega projects.

Table 1: Fellowship visits

Organisation	Type	Location	Purpose of visit
GS Engineering safety school	Civil Constructor	Singapore	To understand approach to workplace safety
BCA Academy (Singapore)	Government Agency	Singapore	To understand approaches to workforce development for Singapore's built environment
ITE	Education Provider	Singapore	Approaches to Industry Collaboration
China Railways Engineering Corporation (CREC)	Equipment Manufacturer	Foshan, Guangdong, China	Training for Tunnel Boring Machines
Guangdong Polytechnic for Water and Engineering (GPWE)	Education Provider	Conghua, Guangdong, China	Approaches to Industry Collaboration
Zentrum am Berg (University of Leoben)	Education Provider	Eisenerz, Austria	Tunnelling Training and Approaches to Industry Collaboration
P4ELECS	Education Provider (KU Leuven)	Leuven, Belgium	Industry Collaboration (onshore wind)
T-shore	Education Provider (Group Syntra West)	Brugge, Belgium	Industry Collaboration (offshore wind)
North American Tunnelling Conference	Industry Conference	Nashville, United States of America	Industry Collaboration /Insights/ Networking

Each of the countries the Fellow visited has adopted and adapted one of the three classical models of vocational education delivery, these are: 1) The Liberal Market Model (Britain); 2) The State Regulated Model (France); 3) The Dual Corporate Model (Germany) (Greinert 2004).

In each of the vocational education models the state, the market and employers had differing roles to influence and direct the why, how, what and to whom vocational education training is provided. Those accessing vocational education and training are either seeking to enter the workforce or are undertaking reskilling/upskilling/licensing to undertake a new job role or gain new skills. The reason for undertaking a training program may either be self-directed or directed by their employer to complete the program. This fellowship has provided the opportunity to examine and understand how education and training providers in different countries have responded to the workforce development and training needs created by mega projects. Specifically, in the context of the dominant vocational education model in which the education provider operates.

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Fellowship methodology

The fellowship project is focused on gaining an understanding of how vocational education providers can build collaborations with contractors designing and building mega-projects. To gather the data and build the knowledge needed to understand how these collaborations are built. The Fellow has undertaken a review of the key literature, undertaken semi-structured interviews with representatives from vocational education providers, OEM and multi-national contractors working on Mega projects. The data and information gathered has then been collated and classified to identify key themes from:

- interviews
- observations from site visits
- presentations from industry
- conference proceedings from the North American Tunnelling Conference.

Observations from meetings held with consortia and joint ventures contracted to build infrastructure as part of Victoria's Big Build program are also referenced in this report.

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Fellowship period

Informally, the planning for this fellowship commenced when the Fellow was asked by the Australian Tunnelling Society in early 2023 to present a paper at the North American Tunnelling Conference in June 2024 (NAT24). The opportunity given to present at this conference then crystalised when the abstract submitted by the Fellow was provisionally accepted in July 2023. This gave an opportunity to then not only gain an insight into tunnelling in North America, but to visit educational institutions with a tunnelling focus whilst travelling to attend NAT24. Application to be granted an ISSI VSA fellowship commencing in October 2023, the fellowship has a twelve-month duration from this date through to October 2024.

06
Fellow biography

Name: Ross Digby

Current Employment: Associate Director-Centre for Energy & Infrastructure, Holmesglen Institute

Qualifications:

- Doctor of Education, University of Canberra, 2020
- Master of Education, University of Melbourne, 2003
- Graduate Diploma in Education and Training, University of Melbourne, 1996
- Bachelor of Business, (Catering & Hotel Management), Victoria University, 1992

Memberships

- Australian Tunnelling Society – member

Biography

Ross is the Associate Director for the Centre of Energy and Infrastructure at Holmesglen Institute and the Victorian Tunnelling Centre. Ross has extensive leadership experience in the VET sector, including the past 16 years at Holmesglen. In these roles he has provided leadership and drive for several innovative initiatives including: the Victorian Tunnelling Centre and HVAC Centre of Excellence. He was the skills and training lead on the Building 4.0 CRC from 2020-2024. More recently, Ross was the TAFE Directors Australia representative on the steering committee for the Clean Energy Capability Study, undertaken by Jobs and Skills Australia.

07

Abbreviations / Acronyms / Definitions

Australian Tunnelling Society (ATS)

Building and Construction Authority (BCA)

BuildSG transformation fund (BTF)

Centres of Vocational Excellence (CoVE)

China Railways Engineering Corporation (CREC)

Design and Construct (D&C)

European Qualification Framework (EQF)

Factory Acceptance Testing (FAT)

Institute of Technical Education (ITE)

International Specialised Skills Institute (ISSI)

International Tunnelling Association (ITA)

Joint Venture (JV)

Land Transit Authority (LTA)

Major Projects Skills Guarantee (MPSG)

Mega project: Any construction project with a value exceeding $US 1 billion dollars

Multi-Service Vehicle (MSV)

National ITE Certificate (Nitec)

North American Tunnelling Conference, June 2024 (NAT24)

Original Equipment Manufacturer (OEM)

Registered Training Organisation (RTO)

Sequential Excavation Method (SEM)

Singapore Bus Service Transit (SBST)

Singapore Mass Rapid Transit system (SMRT)

Tier one contractor: Large construction contractors capable of delivering mega-projects. Capacity to self-perform most of the work on a project.

Tier two contractor: Construction contractors hired for mega projects to undertake specific parts of a project in their area/s of expertise.

Tier three contractor: Small construction contractors that subcontract to tier one and two contractors to undertake specific parts of the mega project.

Tunnel Boring Machine (TBM)

Victorian Skills Authority (VSA)

Victorian Tunnelling Centre (VTC)

Vocational Education and Training (VET)

Zentrum AM Berg (ZAB)

08

Fellowship Learnings & Findings

There is no single approach or process that should be followed by education and training providers when collaborating with entities constructing major infrastructure. There are too many variables that can impact the collaborative models when providing education and training for mega projects. The education and training providers who have the capability to provide training for these projects work within a contemporary educational landscape shaped by government policy, market forces and information technology (Digby 2020). Federal and state governments in Australia play the dominant role in the shaping of this landscape. This includes:

- Provision of funding
- Role in the operation of training organisations
- Regulatory framework within which these organisations operate

Market forces also play a part in the shaping of Australia's contemporary education landscape. These forces include:

- Supply and demand for training,
- Access to the training market
- Costs to enter the market
- Differentiation of product (course or program) in the market.

The role that technology, or more specifically information technology plays in shaping the contemporary education landscape has changed dramatically. No longer is the teacher the keeper of knowledge, their role now is to facilitate learning and skill development. How this is done is increasingly shaped by the use and application of digital technology. The capability and capacity to adopt new technologies into education and training programs is an important factor in the structure of the contemporary education landscape.

The influence of government policies, the role of the education and training market and the impact of information technology need to be understood. Particularly when evaluating the capability and capacity of an education and training provider to respond to the skill needs required to successfully complete mega projects.

The education landscape is not fixed across Australia, its structure differs from state to state and shifts as it responds to changes in government policy, market forces and technological innovation. Those working or entering this landscape may have a different view or perspective on how the education and training system operates, which may consciously or unconsciously impact on how decisions are made in respect to:

- How the required training is delivered
- •Who will deliver the training
- Where training for the project will be delivered.

This is an important consideration when working with multinational organisations, whose executive team's understanding of the contemporary education landscape in a state or country may have been shaped by experiences with education landscapes in other countries in the world. What is consistent across all mega projects when making decisions in respect to workforce development are the following factors:

- Workforce development is seen as cost of construction, not a future investment in workforce capability.
- Workers are paid to undertake education & training (additional cost to project)
- It is preferred that the workers engaged to work on the project already have the skills and knowledge for the role they are to undertake.
- Should skills and knowledge training be required, it is preferable that training be tailored to project need.
- Essential training components could be either accredited or non-accredited and may or may not lead to the achievement of a formal qualification.
- The education and training provider is part of the supply chain.
- Any additional education and training undertaken is usually done to meet contractual requirement/s (for example, Major Project Skill Guarantee (MPSG) in Victoria).

Ultimately the approach taken by multi-national contractor/s to develop the workforce is shaped by their responsibilities to shareholders and the project client.

09
Case Studies

To provide a context to the approaches undertaken to build the capabilities of those working on megaprojects, case studies have been developed from the industry visits undertaken by the Fellow, they:

- outline what training need being addressed
- illustrate how the training is being undertaken
- explain why the training is being delivered in this manner
- identify the workforce capability required by a megaproject.

ITE Singapore

The Institute of Technical Education (ITE) is a post-secondary institution established by the Singaporean government to provide:

- pre-employment training
- continuing education and training for adult learners
- education and training for Singaporean businesses.

ITE has three campuses located across Singapore (East, Central and West). The East and West campuses provide education and training for individuals and businesses working on major infrastructure projects. The training provided at each of these campuses has a focus on meeting specific skill needs for both learners undertaking training to enter the workplace and existing workers who need to be upskilled or re-skilled. Most of this training takes place at the campus in customised learning hubs built in consultation with industry. The hub at the ITE West Campus visited by the Fellow was the ITE Rail Engineering Hub, built with the support of the industry partner: Singapore Mass Rapid Transit system (SMRT). While this is not a training facility that directly supports the day-to-day operations of SMRT, the purpose of the training hub is to build the skill and capability of ITE students undertaking either a Nitec or Higher Nitec engineering sector program. Having completed these programs, learners can progress onto an internship with SMRT. The curriculum for the program is developed by ITE with industry consultation from SBST/SMRT/LTA. The facilities in the ITE Rail Engineering Hub include a replica platform with doors, MRT Carriage, traction control set, and track section designed for training in rail jointing and fastening. The supply of this equipment was funded by ITE and the Ministry of Education. The tuition fees to undertake this program are paid by the learner, but these fees are heavily subsidised by the Singapore Government for Singaporean nationals.

Figure 2. MRT Carriage customised for training programs at ITE West Campus, Singapore

Figure 3. MRT track sections, in engineering workshop at the ITE West, Singapore. Students are trained in Thermite welding.

Building Construction Authority-Singapore (BCA)

ITE has a focus on educating Singaporeans who have selected a vocational education pathway, BCA is focused on the delivery of programs for the built environment including major infrastructure projects. These programs range from the accreditation of foreign workers in basic construction skills through to degree programs. These programs are delivered in conjunction with universities and colleges in Asia, America, and Europe. The BCA is funded through a levy imposed on building projects being undertaken in Singapore. This levy and other industry development support programs are managed under the umbrella of the BuildSG transformation fund (BTF). This is in addition to the tuition fees paid by the learner or their employer. In some situations, the tuition fee component is subsidised by the government. The BCA also provides scholarships for workers in the sector to upskill and reskill, not only at the BCA, but also at universities and polytechnics in Singapore. Due to the small population in Singapore relative to the large number of built environment and major infrastructure projects under construction, Singapore has imported low skilled workers from Bangladesh, India and Myanmar. Before commencing work in Singapore, they must attain a skill proficiency certificate for each skill area they will work in prior to being issued with a Singapore construction work pass. The assessment has a written (knowledge) component, and a practical test component. The assessments are conducted in the workers' country of origin and must be obtained prior to entry into Singapore. The employer of the workers facilitates the trade testing process. This process is designed to ensure that foreign workers have the skills required for the role they are employed to undertake, the foreign workers will be paid correctly, and workers have an awareness of workplace safety on building and infrastructure projects.

GS Safety School

The GS Safety School is an initiative of GS Engineering & Construction, a Korean owned multi-national tier-one contractor. This training facility has been established to raise awareness of safe work practices on major infrastructure projects they are working on in Singapore. Following the Nicol Highway collapse in 2004, the Singaporean government has introduced a range of measures to improve workplace health and safety on building and major infrastructure projects. The safety school has been built to provide training support for tunnelling projects being undertaken by GS Engineering & Construction in Singapore. The overarching objective of the training provided at this facility is to raise awareness of:

- The role of workers to improve and maintain workplace safety.
- Unsafe work practices.
- Unsafe zones in the workplace.
- How to respond appropriately if they find themselves in an unsafe situation.

Each simulation requires the worker to physically engage in the simulation. For example, the trench

collapse simulation requires the participant to stand in a simulated trench and have the walls collapse onto the participant (padded buffers that push out from either side of the wall to squeeze the participant). Other simulators include:

- Falling into opening
- Truck rollover
- Slinging loads
- Excavator exclusion zones
- Hand injuries
- Safety harness
- Confined spaces
- Scaffold collapse.

Each simulation has activities built into it that raise the awareness of the worker of the hazards associated with an activity and the potential risks. Having then been exposed to the risk, by undertaking the simulation, the worker's awareness has been raised and learning maximised through the utilisation of touch/feel in addition to auditory, visual, and verbal interactions with the simulation and the trainers at the safety school. The training provided at the safety school is not accredited as it is delivered to all levels of worker on the tunnel project, including engineers, administrative and other support staff. This has been done to demonstrate GS Engineering & Construction's commitment to safe work practices through their direct delivery of safety training and not using a third party to deliver the training. The safety only focus of the school also enables it to:

- Respond appropriately to safety issues identified on the project
- Adjust the training to respond to the risk
- Upskill/retain workers to mitigate risks associated with the identified hazard/s on the project.

Interestingly, when the Fellow told educational providers in Singapore of the work being undertaken at the Safety School, they were not aware of the GS Engineering & Construction's safety school.

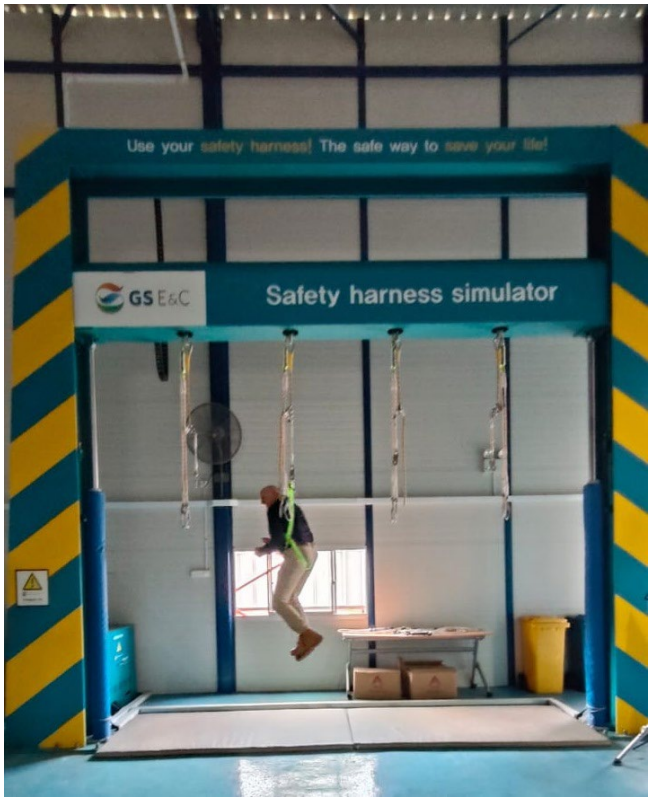

Figure 4. The Fellow testing the Safety harness simulator at the GS Safety School, Singapor

Figure 5. The Fellow preparing to experience the fall into opening simulator

China Railways Engineering Corporation

China Railways Engineering Corporation (CREC) builds infrastructure to support the construction and operation of railways and major infrastructure in China and across the world. This includes the recently opened fast train link between Jakarta and Bandung in Java, Indonesia. The manufacture of Tunnel Boring Machines (TBM) is a focus of CREC. In 2023 CREC received orders to manufacture 248 TBMs. These TBM will be deployed to Tunnelling projects in China and other parts of the world. At the time of writing there are several CREC TBM to be deployed to tunnelling projects in Australia including Snowy Hydro. To manufacture this number of TBM every year CREC has 18 manufacturing plants with 56 assembly lines across China. The Fellow visited the CREC TBM manufacturing facility in Foshan, Guandong Province. The purpose of the visit was to look at the TBM manufacturing process and understand training approaches to operate and maintain TBMs. The visit of the Fellow coincided with the final stages of factory acceptance testing (FAT) of a 14.43 metre in diameter TBM to be deployed to construct a tunnel on the Shenzen to Shantou high speed rail link. As the TBM was to be shipped to the tunnel portal approximately two hours after the factory visit, the Fellow was able to inspect a completed TBM and gain a detailed insight into the skills and trades utilised to manufacture a TBM, the process of production and time taken to manufacture the TBM (approximately 10 weeks from start to completion of factory acceptance testing). As part of the visit the Fellow inspected a TBM constructing a 6 km tunnel that will make up part of the Guangzhou to Zhaoqing high speed rail link. This tunnel is being constructed with a 14.29 metre diameter slurry and hard rock TBM. At the time of visiting, 748m of the tunnel had been constructed. As with all tunnelling projects across the world, the number of workers underground is kept to a minimum with no more than 12 workers operating the TBM at any point in time. During the Fellow's time underground, he observed the:

- Operation of the TBM from the operator's cabin.
- Transfer of a tunnel lining segment from the multi-service vehicle (MSV) to the segment loader.
- Slurry pump processes
- Conveyor belt with spoil from the cutter head.
- Bentonite processing plant.

Training of workers who operate and maintain the TBM's CREC has a collaborative approach with the lead contractor or Joint Venture (JV). CREC deliver a range of specialised training in the operation and maintenance of TBM for its workforce and for contractors who are using CREC TBM's. Each of these training units are accredited by CREC. Some of these programs are delivered in intensive training blocks, while other training programs are delivered utilising an apprenticeship delivery model. For example, workers being trained to operate a TBM on the Guangzhou to Zhaoqing project undertake a ten-day training program over a six-month period.

CREC provides a range of training programs for the operation and maintenance of TBM. This includes:

- Electrical
- Instrumentation
- Fabrication
- Mechanical services
- Hydraulics, and
- Segment lifter/erection operation.

On mega projects in China, it is the contractor who determines the training required for workers on the project. The provincial government has little if any input into the training of workers for a project. The workforce for these projects is highly mobile, and in most cases live in workers huts located on the project site. The opportunity to see both the manufacture and operation of TBM on the same day was one of the highlights of the fellowship and gave the Fellow a unique insight into the scale and scope of tunnel construction and the training needed to meet the demands for tunnelling in China.

Figure 6. The Fellow standing in front of 14.43 metre diameter cutterhead at the CREC TBM factory, Foshan, Guangdong, with Scott Ma (CREC), Chuyin Zhong (interpreter) and Yan Lee (interpreter),

Figure 7. Control room on TBM constructing the Guangzhou to Zhaoqing high speed railway, Guandong, China

Guangdong Polytechnic of Water and Engineering (GPWE)

GPWE is a specialist high-level vocational polytechnic located in Conghua, Guangdong. About 65 km northeast of Guangzhou. This area of Guangdong provides Hydro-electric generation for the province. GPWE delivers a range of vocational qualifications in engineering, electrical and energy generation to support the electrical generation industry in the Conghua district and nearby regions. The collaborations that GPWE have with the water and engineering industry are very strong. This is in part due to government mandating that industry collaborate with the college to provide student placements and industry support and consultation to program development and design. GPWE also place a strong focus on their industry connections for all staff, again this is mandated and supported by government. The programs delivered at GPWE have a duration between six months and one year at the associate degree level and are focused on vocational pathways to work in the hydroelectric and renewable energy sectors. As the collaborations between GPWE and industry are built around a centrally driven and mandated structure, the relationship between the GPWE and industry is based on a model of accredited programs for industry. The concept of providing bespoke non-accredited training programs based on project or industry need is not addressed in the approach of GPWE to meet the needs of industry. This was reiterated during the site visit with CREC.

Zentrum AM Berg (ZAB)

Located in Eisenerz, Stryia, Austria. ZAB is a unique training facility for underground construction and operations. Operated by Montanuniversitaet Leoben, the facility includes:

- Two parallel road tunnels.
- Two parallel railway tunnels
- A test tunnel, and
- Other underground spaces.

In total there are four km of tunnels in the network, repurposed for education, research and training.

The facility (opened in 2019) is located at the Erzberg mine. This mine has operated continuously since 1512, originally using both underground and open-cut mining techniques, mining Iron ore (siderite and ankerite). The mine is currently producing approximately 7.2 million tonnes of ore at 40% concentrate per annum. The Iron ore from this mine is used in the manufacture of the groove rail track installed on Melbourne's tram network. The versatility of the tunnel forms at ZAB has enabled an almost unlimited range of education, training and research activities to be undertaken in the construction and operation of tunnels. While the Fellow was visiting the training facility, emergency services personnel were undertaking training in one of the road tunnels. This is one of the key training activities undertaken at ZAB. When undertaking these activities, emergency services personnel are:

- Being trained to undertake evacuations from road/rail tunnels
- Strategizing and testing evacuation scenarios
- Testing firefighting/suppression systems

Figure 9. Heat shield in two lane road tunnel at ZAB, Eisenerz, Stryia, Austria

Figure 8. One of the original iron ore mine tunnels at ZAB, Eisenerz, Stryia, Austria

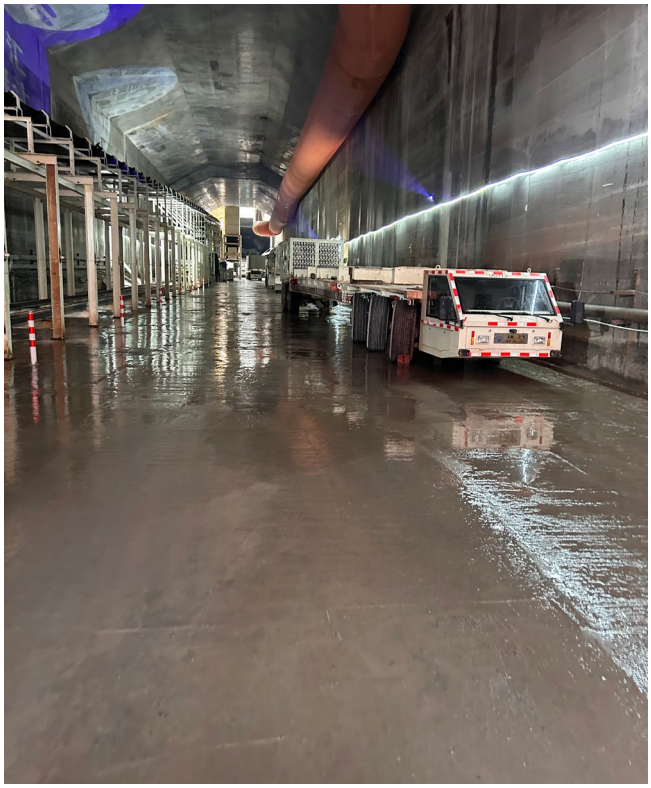

Figure 10. Two lane road tunnel at ZAB configured for vehicle rescue exercises

One of the road tunnels is fitted with a heatshield to minimise damage to the tunnel walls when setting vehicles on fire in this controlled environment. A supporting training and seminar centre are on site to support training activities.

The scope of the training facilities at ZAB have enabled Montanuniversitaet Leoben to provide users a diverse range of education and training options. The accredited training provided at ZAB is in the higher education sector, a Bachelor program in mineral resources engineering and a Master program with a focus on geotechnic and tunnelling. The Tunnelling facility enables learners to undertake practical learning about:

- Tunnel construction techniques.
- Construction and testing of tunnel lining segments.
- Soil and rock mechanics.
- Digital modelling in underground spaces and,
- Operation/maintenance of tunnels.

The tunnel spaces at ZAB are also being used for a range of applied research projects commissioned by both industry and government. The impact that ZAB is having on setting the standard of tunnelling education and training cannot be underestimated. Specialised training centres across the world such as ZAB and the VTC are actively engaging and collaborating to ensure tunnellers are trained to world best practice standards to ensure tunnels and underground spaces are constructed and operated safely and efficiently.

Figure 11. The Fellow at the entry to ZAB

Erasmus Projects

The European Union in response to the dynamic changes in society impacting on:

- Workforce mobility
- Multiculturalism
- Digital innovation, and
- Transition to a green economy

have established centres of vocational education excellence (CoVE), funded by the Erasmus project. The Centres of Vocational Excellence (CoVE) project is designed to develop high quality skills and competencies that meet the “needs of an innovative, inclusive and sustainable economy” (European Union, 2023, pg 257). The Fellow met with representatives from two CoVE projects to understand how the projects have responded to the identified challenges. Both projects are focused on the provision of education and training of workers required for the transition from fossil fuels to renewable energy.

P4ELECS

Focus on electrification, aiming to reduce the time to transition from research to implementation for new technologies to support this transition. P4ELECS is a collaboration of industry and tertiary education providers across Belgium, Germany, Italy, Latvia and the Netherlands. Aiming to build flexible learning pathways that will enable learners to move into key employment roles. The collaboration is developing 200 building blocks of knowledge that can be combined into courses or delivered as micro-credentials. The objective of this structure is to enable the packaging of the building blocks to meet local needs of a particular learning environment. The building blocks can also be delivered in project-based development model of:

- Conception
- Design and Engineering
- Implementation, and
- Operation.

The building blocks are set for delivery to learners at the EQF 5-8 levels. Although this model has enabled the P4ELECS CoVE to bring together a wide range of educators and industry across Europe, enabling collaborations to access industry current skills and knowledge to build training programs that meet current and future workforce development needs. It was acknowledged that this part of the process worked well. Unfortunately, the accreditation process for vocational education programs in the European Union is not keeping pace with the need to accredit qualifications needed by industry to train workers in new technologies. The delay caused by the existing accreditation processes has resulted in some of the accredited blocks of skills and knowledge no longer being current due to the rapid rate of change in technology being used in the renewable energy sector. The P4ELECS credential model also enables a range of learners in different stages of their career pathway to undertake education and training to either enter a career, upskill or reskill to work in the renewable energy economy.

T-Shore

T-Shore is a CoVE collaboration and is focused on the development of education and training programs to address the skill needs in the offshore wind industry. There are 13 industry and education partners in the T-Shore CoVE, they are from Belgium, Ireland, The Netherlands, Denmark and Norway. The Fellow met with representatives from Syntra West/Skilliant located in Brugge, Belgium. The Belgian CoVE for Offshore Wind Energy CoVE operate the 'The Reef' training facility in Ostend to service offshore wind farms and Princess Elizabeth Island and artificial energy island being built in the North Sea. The objectives of the six CoVE's that make up T-Shore are to:

- Collaborate to share best practice in education and training for offshore wind projects.
- Harmonise and deliver high quality training for entry level wind technicians.
- Collaborate with the offshore wind industry, understand the key competencies required to meet the offshore wind industry needs.
- Build the capability and capacity of educators and trainers through exchanges, cross validation of education and training resources, and
- Undertake ongoing professional development in industry.

Within T-Shore each education provider works at country level to build collaborations between industry, vocational education providers and government. The collaboration between each T-Shore CoVE is focused on the identification of best practice in the provision of education and training, collaboration to effectively and efficiently develop resources based on the strengths of each T-Shore and building the skills and capability of educators and trainers. The T-Shore CoVE is focused on the employment and skill development outcomes of the learners. The issue of qualifications was not raised by the representatives of T-Shore the Fellow met with as being an objective of the CoVE. This differs from the comments made by representatives from P4ELECS who were frustrated with the time taken to accredit qualifications for new technologies and innovation in the renewable energy sector.

North American Tunnelling Conference (NAT24)

The North American Tunnelling Conference held in Nashville, Tennessee provided the opportunity to gain an insight into the latest innovations and issues facing North American Tunnellers. The conference enabled the Fellow to gain an insight into the education and training of tunnellers in North America. The themes that came through at the conference that need to be considered in planning for the provision of training for future tunnelling and other mega projects (SME, 2024), include:

- Construction of tunnels and underground spaces to mitigate the impact of climate change.
- Refurbishment and reuse of tunnels.
- Tunnel ventilation and use of life-saving technologies.
- The use of automation and artificial intelligence in tunnel design, construction and operations.

- Differences in approaches to planning, design and the management of major infrastructure projects.

The utilisation of tunnels and underground spaces to counteract the impact of climate change was identified in a range of the papers delivered at NAT24. This included the rehabilitation of tunnels for the movement of water to reduce the evaporation of water and underground spaces for the storage of water. This will require educators to move the focus of training and understanding of tunnel types and underground spaces beyond those used for transportation.

Several papers focused on the renewal of tunnels to integrate into new transportation systems and utility servicing. In these presentations the focus was on the refurbishment of tunnel supports and linings, particularly to ensure these linings are impervious to water penetration. These presentations covered topics such as jet grouting, lining materials, tunnel reinforcement techniques, this includes processes to replace timber supports, installation of concrete segment lining. In undertaking works of this nature, there was also a focus on hazard identification and how the resultant risks can be mitigated and eliminated.

Figure 12. The Fellow delivering research paper at NAT24, Nashville, Tennessee, USA

As the use of tunnels to transport people on road and rail increases, the importance of ensuring the safety of those using and working in the underground environment is of utmost importance. Several papers presented at the conference covering this theme focused on the convergence of artificial intelligence, robotics and automation to monitor, identify and maintain systems to provide essential utilities and manage people, vehicles and other materials transferring through tunnels. These activities are not undertaken by tunnellers, rather they are undertaken by mechanical services plumbers, electricians, and other trades. The technical nature of monitoring, evaluating and then modifying or repairing equipment needs a specialist tradesperson. This person needs to have capability to not only perform physical tasks, but they also need to have the capability to analyse, interpret, and understand data from a range of monitoring devices and then implement actions to address the matter in the underground environment.

The impact of artificial intelligence, machine learning and automation is changing job roles and work processes for the design, construction and operation of tunnels and underground spaces. These technological innovations will fundamentally change the role of the tunneller. This will shift from operating a machine to excavate a section of the tunnel in accordance with the issued permit to tunnel, to that of a technician gathering and interpreting data from different sources. In turn, this data will require analysis and interpretation to determine if tunnelling is proceeding in accordance with the permit to tunnel and informing planning for the next phase of tunnelling. Technological innovations in the construction and operation of tunnels will impact all roles in the construction and operation of tunnels and underground spaces. Again, education and training for tunnellers will need to shift focus from merely operating equipment to building skill and capability to observe and interpret data and then adjust the operation of equipment as required.

The dominant training model for workers constructing and operating tunnels and underground spaces in the USA is to undertake a fulltime diploma level program with a duration of 10 months. They then take up employment with a tradesperson, work as an apprentice for 4-5 years and then undertake assessments and examinations to be an accredited

tradesperson. There was very little discussion about the interface between professionals and tradespeople on projects at NAT24.

Presentations made at NAT24 about approaches undertaken in contracting processes for megaprojects provided the Fellow with an opportunity to reflect on how these processes can be applied to the Australian context. The commonly used process is known as design-bid-build.

Design-Bid-Build/Design-Build

This methodology requires the contractor to design a solution to meet the client need prior to bidding for the project. The project is then bid for by contractors who may be selected on one or several criteria. Finally, the project is then built. Although this methodology is widely used in the civil construction sector, there are often unrealistic expectations in tunnelling projects when the sub-surface conditions are not understood. Consequently, the bid for the project is based on the available data on sub-surface conditions provided by the client (for example a state government). This places unrealistic risk expectations on the lead and sub-contractors. It can impact on the design solution, leading to project cost overruns as the contractor did not anticipate the design changes required during the bid phase. Similarly, a design-build approach will have a contractor undertake both the design of the project solution and the build of the project. As with the design-bid-build process, an unreasonable risk expectation is placed on the contractors. Both fixed pricing approaches can be described as unrealistic as they do not factor an appropriate assessment of risk and contingencies associated with design modification due to unanticipated changes in sub-surface conditions (inset citation Bhattarai & Hatem, NAT24).

Early Contractor Involvement

The adoption of the Early Contractor Involvement approach to contracting for major projects provides the opportunity for selected contractors to be involved in the project in the design stage to utilise their knowledge to:

- Identify required equipment and skills,
- Identify potential hazards and risks mitigation, and
- Provide improvements/amendments to the works design.

This is then used to enable agreement on the project price and allocate risk between the project owner and contractor/s. This approach will continue throughout the project allowing for modification and variation in the project. Early contractor involvement also has application to the provision of training for mega projects when the training requirements cannot be determined. This may be due to a lack of knowledge about ground conditions and other variables. The unknown training needs can be further exacerbated when new technologies and equipment are introduced to the project. This is happening on mega projects that may have a duration of more than 5 years. While the costs of training on a mega project are not a significant part of the project budget, not having a trained workforce will impact on the quality of the work done and can impact on the project being completed on time and on budget. The earlier key education and training providers can be involved in determining training solutions the better the training outcomes.

10 Considerations and Next Steps

The insights, observations, and knowledge attained by the Fellow in undertaking this fellowship form the basis of how to identify the skills, knowledge and capabilities required for mega projects. In this context, while the project may generate thousands of jobs, it requires different skills and capabilities at different stages of the project. So that the workforce has the required capability and capacity to complete mega projects, it is critical that the education and training provided to workers on these projects:

- Ensures that training builds the capability and capacity of workers to analyse and interpret data. It should not only focus on the performance of tasks by hand.
- Considers the speed at which technology is changing equipment, construction techniques and other processes across all industry sectors now requires workers to have the capability to adapt their skill and knowledge to use new equipment, techniques and equipment.
- Ensures that the workforce has the capability to adapt their skills to new job roles and environments.

In the provision of training for megaprojects, the focus needs to be on building an understanding of the context and environment in which they will be working. In this dynamic environment, technology and processes in the workplace will constantly evolve and change. To ensure that the workforce can continually develop their skills and capability, the Fellow has formed the opinion that there is a need to differentiate the training provided to new entrants to the workforce, as opposed to the training to be provided to the qualified/licenced workforce.

New entrants to the workplace need to develop a range of core skills that will enable them to gain recognition as a tradesperson or achieve professional association accreditation. New entrants also need to develop the capability to adapt these skills That is they will need to have the capability to identify, understand and adapt their existing skills by having capability to problem solve, interpret and comprehend documentation, teamwork, digital literacy and change management capability.

For those workers who are qualified professionals or tradespeople, the training focus should be on adapting existing skills to new processes, techniques and capability to understand and use digital technologies. This is a focus on developing capability to:

- Solve Problems.
- Interpret and comprehend documentation.
- Work in a team
- Build digital literacy and
- Effectively enable change management.

Ideally, in the context of the environment in which they are working.

In the context of mega projects such as tunnelling and offshore/onshore wind turbines, the core skills that many workers will require are very similar to those skills they are already competent in. It is the working environment, equipment and processes which are new. The focus should then be on building the capabilities that enable these workers to adapt to not only this workplace but to other future job roles, work environments, equipment and technologies used on the projects of the future.

From the perspective of the lead contractor, education and training is merely another widget in the project supply chain. In a perfect world the workers coming onto the project would have the skills required for the role being undertaken on the project. For the lead contractors on many of Victoria's big build projects, this has not been the case. The need to meet the requirements of Victoria's major project skills guarantee (MPSG), has required some big build projects to adjust their core training needs to meet the guarantee, rather than critical project training needs. The accredited training that is then provided to meet the MPSG requirements is designed to meet the short-term project needs, which may or may not be of long-term benefit to the individual or Victoria's economy. The focus of training and upskilling for major infrastructure projects, has been on:

- Corporate and operational processes and objectives supporting the project
- Safety systems and processes to be used on the project
- Specialist construction techniques required for the project
- Operation of bespoke equipment and plant required on the project

The training needs can be further complicated when workers need to gain international accreditation. For example, workers applying sprayed concrete underground (shot crete) need to gain EFNARC certification to be a Nozzle Operator. The Australian unit of competency, Apply Shotcrete Underground is not considered to be appropriate or adequate to accredit workers by the suppliers of Shotcrete equipment and shotcrete materials. The requirement of suppliers to have workers complete certification such as EFNARC further complicates how a registered training organisation responds to the training needs of a mega projects. For an RTO to gain accreditation the EFNARC nozzle operator certification is costly. Even more so when only a small number of workers require accreditation. In this case it will not be financially viable. The challenge for mega projects, particularly those projects with a large tunnelling component, is to ensure they have access to workers with the skills, knowledge and capability required for the project. Training providers need to have the capability and means to efficiently collaborate with contractors to deliver the training required, be it accredited or non-accredited within the Australian legislative framework.

In responding to a request to provide training for a mega project, a competitive tender process may not provide the project, the taxpayer or the workforce with the best training outcome. Yes, a competitive price may be achieved for the contractor/s. However, the training solution is unlikely to meet project need when focused only on accredited training. To meet the training needs of mega projects, the training provider/s need to be involved in the project at a very early stage (ideally design and preliminary planning) to gain a deep understanding of the project in terms of:

- Governance structure
- Construction challenges
- Project phases
- Preferred equipment suppliers
- Training requirements of equipment and materials suppliers
- Project schedule and critical project paths
- Existing workforce capability
- Required workforce training needs

The impact of new technologies and environmental/ sustainability requirements also impact on the provision of training to mega projects. particularly when projects have a duration over many years. Training providers need to have the capability and capacity to quickly integrate the new technologies or standards into the training provided. They also

need to work with accreditation authorities (state/ nationally) to have the new training programs appropriately accredited in time to meet project needs. This is a costly process requiring substantial input from:

- Subject matter experts.
- Equipment and materials suppliers.
- Instructional designers.

particularly when equipment suppliers are located overseas and are unlikely to donate or subsidise the cost of equipment required to deliver the program. This may be mitigated when the education/training organisation is involved in the early stages of the project and these costs or arrangements to share costs can be negotiated.

The reasons to move away from a competitive tender approach to a model that enables key training providers to work with lead contractors and/or statutory project authorities are compelling. There are too many unknowns and variables during the design and early stages of mega projects that impact on the design of a comprehensive training solution that meets project training needs for the duration of the project.

11
Impacts of Fellowship

This fellowship has provided the Fellow with the opportunity to reflect on several dimensions of the contemporary education landscape in the context of providing education and training for mega-projects. The Fellow has also been able to enhance existing relationships and build new relationships with organisations undertaking training for mega-projects in Asia, Europe and North America. The impacts relate to five areas of insight:

- The international tunnelling community
- Approaches of multinational contractors to training
- Models of collaboration between educators and industry
- Innovation through industry collaboration
- The need to train workers to adapt their capabilities in the digital age
- When engagement should take place between contractors and education providers

International tunnelling – a community linked through a shared safety focus

The Fellow has close to 30 years' experience in the vocational education sector across a range of industries. Each industry sector has its unique characteristics and approaches to building skills and capability. The tunnelling industry in Australia is unique to its approach to the training and development of its workforce. The workforce is very mobile and will follow the work around the country and internationally. The skills they require are drawn from a wide range of trades and adapted to tunnelling operations. There are different tunnelling techniques that utilise different equipment, depending on the ground conditions, availability of equipment and the end use of the tunnel. The tunnelling sector is continually adapting new technologies and are collaborating, not only within their country, but internationally to make tunnelling more cost effective and above all safer. Those within the sector see safety as being the single most important item to consider in a tunnelling project. It is this dedication to doing things safely that underpins the collaboration across all levels and occupations to share best practice in tunnelling techniques and safety. This shared understanding enabled the Fellow to quickly build a rapport with tunnellers and tunnelling educators across the world who were only too happy to share ideas and their knowledge regarding the education and training of tunnellers.

Differing approaches of multinational contractors to training

Due to the size and scope of mega projects (tunnelling, offshore/onshore wind energy generation, and other projects), lead contractors will on most projects collaborate with other contractors/organisations to undertake the project. In the Australian context these collaborations often have a foreign company leading the collaboration. Understanding the make-up of the collaboration can help in understanding how it will approach the training and development of new and existing workers on the mega project. While there may be government requirements regarding

the skilling of the workforce, how the collaboration achieves this is often based on their approach to training, not only in Australia, but internationally. Although the training and upskilling of workers is important, it was clear to the Fellow that training and development is just another project input to be considered.

Models of collaboration between educators and industry

How a lead contractor or joint venture works with education and training organisations can be shaped by several factors, including:

- Existing workforce capability.
- Skills needed for the project.
- Previous training collaboration experiences
- Education and training models in other countries
- Contractual requirements to provide training to the local community

Each of these factors shape the approach taken when the contractor determines the training and development needs for the project. The contractor will also need to consider the capability of education and training providers to meet their training needs. Particularly when the speed at which technology is changing equipment makes it almost impossible for any single education and training provider to have the capability to maintain currency. This has implications for regulatory authorities who also need to update and maintain accreditations to ensure that qualifications granted maintain their industry relevance.

Innovation through Industry Collaboration

Examples of innovative training approaches that resulted from effective collaborations with industry were observed by the Fellow on several of the site visits undertaken. This included the rescue training at ZaB, the SMRT engineering facility, HVAC and fire safety systems at ITE EAST and the maritime training undertaken by T-shore. Discussions were held with each of these organisations as to how they gained the support of industry to provide equipment and supporting resources to undertake training. It was not a case of the education provider taking a course to the organisation and trying to get them to provide support for the program. In each case the training organisations went to industry to gain an understanding of what their current and future training needs would be. Each of these education and training providers then worked with industry to determine how they could best address the training need. The focus was not on what they needed to learn, rather how they could best build the capabilities and skills required by these organisations. At each training organisation, the equipment and facilities provided or recommended by industry were designed not only to teach learners (including workers from the supporting organisation), but to enable the learner to build their capabilities. These capabilities included digital thinking, problem solving, and the integration of new processes and technologies. Recognition for the training undertaken may in some cases be government accredited (predominantly in Europe), but in other jurisdictions, the training may have been accredited by the OEM, or by the employer funding the training.

Training workers to adapt their capabilities to the digital age

The advance in digital technologies has seen many tasks and processes replaced by robotics and automation. They are also integrating artificial intelligence into their operations. The tunnelling industry have embraced the integration of digital technologies into the design, construction and operation of tunnels and underground spaces. The reasons for the industry embracing digital technology include the:

- Removal of people from high-risk areas.
- Ongoing assessment of ground and atmospheric conditions in tunnels and underground spaces.
- Productivity and the quality of work undertaken.

The impact that this has had on the Fellow is to rethink how we approach the training of workers. The focus needs to shift from training a worker to apply a skill to a specific task in a specific industry, to one of training workers to understand and undertake a skill

and then apply the skills across a range of tasks and industries utilising digital technologies.

The timing of engagement between contractors and education providers

The Fellow's involvement in three major tunnelling projects has provided an insight into when education providers should engage with contractors in the planning and delivery of training for a mega project. The preferred model that is commonly used in Australia is for the lead contractor to tender the training component once the company has won the tender to undertake the work. Although this approach is designed to ensure fairness and best price, the unknowns faced by the education provider in understanding detailed project training needs can be overwhelming. An preferred approach should be to involve appropriately experienced education providers in the early-stage planning process for the project. They then gain a deep understanding of the project training needs based on ground conditions, workforce capability and project design. This then enables the education providers to plan, prepare and implement the appropriate training when required. This increases the likelihood that new units of competency required for the project can be developed and accredited ready for delivery when the industry or project requires the training to be delivered. The issue of the accreditation not keeping pace with project need, or as identified on the CoVE projects, not keeping pace with technological change, is another priority. The sooner education and training providers can meaningfully engage with lead contractors and statutory authorities to determine project education and training needs will lead to cost-effective education and training out comes.

Wider impacts of the fellowship

The models and approaches to collaboration observed by the Fellow have application to other industry sectors. While the number of workers in organisations in other industry sectors may not be as big as a megaproject workforce, some of the insights gained by the Fellow have application beyond the infrastructure sector and can be applied to other industries. The process of planning and implementing a collaboration with industry, has application across most industries. Understanding why training is required by an employer or a wider industry is critical in building effective collaborations. It is important to underlying reasons why training is required and there is a need to understand the factors that have influenced that decision enable a training solution to be developed. A key part of this solution is the integration of technology into the training solution. The application of the technology also needs to be designed to enable the learners to develop their capability to use digital technologies and apply this thinking to tasks and processes being undertaken. These approaches should enable training providers to develop enduring collaborations with industry and provide education and training programs that build digital capability in the learners and have a sustainable benefit for the organisations involved.

12

Sector Engagement (Dissemination):

The Fellow has made several presentations to conferences both within the organisation he is employed at, and presentations made at the Victorian Skills Authority, SEABX Mission to Indonesia and Vietnam: Skills for a Greener Future, OctoberVET. The learnings gained from the fellowship have also been incorporated into the day-to-day work undertaken by the Fellow on major project work currently being undertaken in Australia.

These projects are being undertaken by the Fellow's employer and other TAFE organisations who could provide training to major projects. The release of this report will lead to a further opportunity to disseminate the experiences and findings from this fellowship. Table 2 outlines the activities undertaken, focus of dissemination and events activities undertaken

Table 2. Dissemination of findings from fellowship by activity type

Activity	Target Audience	Focus of Dissemination	Events/Activities undertaken to date
Conferences	Educators & trainers from RTO's and other individuals	Research methodology, key findings from the fellowship, opportunities for further research	Holmesglen staff development conference. OctoberVET, AVETRA conference
Partnerships with TAFE's	TAFE institutes collaborating to provide education and training to major projects	Strategies to enter effective collaborations with contractors and joint ventures tendering for major infrastructure projects in Australia	Meetings with TAFE institutes to discuss collaboration to enable the delivery of education and training to major infrastructure projects in Victoria
Future Megaprojects	Lead/sub-contractors, government agencies,	Overview of key findings resulting from fellowship and next steps to advance findings	Presentation to staff from Victorian Skills Authority

Activity	Target Audience	Focus of Dissemination	Events/Activities undertaken to date
Interstate training providers	Collaboration with Interstate TAFE institutes and RTO's	Strategies for effective collaboration,	Discussions held with interstate RTO's regarding their collaboration with major projects in their jurisdiction
International	Civil Engineers and Infrastructure managers offshore	How workforce development on pumped hydro projects can be used to facilitate community engagement and develop skills in local communities.	Meetings and presentations with representatives from pumped hydro projects in Bhutan, Nepal, Pakistan and Vietnam
Applied research	Researchers who have interest in the VET Sector, workforce development and infrastructure development	Research methodology, key findings, opportunities for future research	Meetings with researchers at Monash, Swinburne and Deakin Universities. Presentations at AVETRA and OctoberVET

13 Conclusion

The fellowship has provided the Fellow with the opportunity to investigate, evaluate, reflect and build a deeper understanding of education and training practices utilised for mega projects across the world. A critical element of this understanding is the effective collaboration between educators and megaproject contractors to respond to the training needs of the project. This builds the skill and knowledge capabilities of existing and new workers on these projects. The sheer size and scope of Megaprojects in terms of:

- Project costs.
- Number of tier-one, tier-two and tier-three contractors engaged.
- Scope of plant, equipment and materials required.
- The utilisation of cutting-edge technologies (robotics, automation and artificial intelligence)

a cause for education providers to reflect on how they educate and train for mega projects. Training providers need to have a business-to-business focus when responding to the training needs of mega projects.

Training providers need to effectively respond and make sense of the operational landscape within which the lead contractor/s operate. Specifically, how multi-national contractors perceive how education and training providers should respond to project training requirements. This includes training subsidies, training guarantee requirements, and the role of government bureaucracy in the regulation of education and training. All of which may be viewed and commented on by the multi-national contractor through the lens of educational landscapes they have previously operated in. It is important that the education and training providers understand the governance and corporate structures underpinning the delivery of the project. This impacts on the stage at which the education and training provider can be involved in the project, how decisions will be made by the contractor/s and who the education provider will be contracting with. Although these factors should not impact the day-to-day delivery of training, it may impact how quickly the project and educational providers may work through pre-tender, tender and contracting phases prior to the delivery of training.

The primary objective of the contractors delivering the project is to complete the project on time and on budget. It is not a primary objective of the contractor to build local workforce capability. By nature, the core mega project workforce moves from project to project, across states and sometimes countries, reducing the need to train large numbers of workers for an extended period, as would happen for a large manufacturing project located on the same site for decades. The training priorities of the mega project are focused on safety induction, reskilling, upskilling and verification of competency, and the workers who undertake the training are being paid to train. For the education provider to effectively work within this paradigm, the provider needs to understand that they are part of the supply chain within the ecosystem of a megaproject in which both accredited and non-accredited training components are required. These skills are generally not unique to the project. What is unique is the environment in which they are

performed. Be that in a tunnel, or on a ship as would be required for an offshore wind energy project. The focus for workers who are moving between these projects should not be on merely performing the skill, the focus needs to be on building the capabilities to incorporate new technologies into their job role and understand, evaluate and implement these technologies. Not only for their job, but how to apply, operate and evaluate new technologies in future job roles.

While the focus of this fellowship was on the provision of education for megaprojects, specifically projects with a large tunnelling component. The findings have application beyond infrastructure megaprojects. How TAFEs and other RTOs collaborate with the lead contractors or joint ventures should have applicability to a wide range of industry sectors. Particularly the process of understanding how the lead contractor or joint venture perceives how education and training should be provided for the project.

The findings presented in this report have application beyond the provision of education and training for megaprojects. The Fellow observed on several occasions when undertaking the fellowship, strong collaborative approaches between the business and the training provider. Each organisation was focused on meeting the training needs of the organisation. The needs of the individual student, while important, did not have the highest priority. It was clear that the focus was on completing the project on budget and on time. This objective is not only applicable to megaprojects, but all organisations also want to achieve this objective. When training providers view workforce development needs from the perspective of the employer, the ability of the training organisation to respond effectively and efficiently is enhanced and builds a sustainable relationship been organisations.

Mega projects can incur cost blowouts when preliminary project planning is not done correctly. Likewise, when the education and training requirements for a megaproject are not understood or the information provided is inadequate, there will be cost overruns. To address this, the earlier that appropriately experienced and qualified educational organisations can become involved in the project, the more likely it is that the education and training provided to the project will meet project needs and build local skill capability in a sustainable manner.

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