VICTORIAN TAFE ASSOCIATION

# Applied Research and Innovation in VET

*Discussion paper: What do we mean by applied research and innovation in VET?*

# Contents

## Introduction

This Discussion Paper was commissioned by the Victorian TAFE Association (VTA) as background for a discussion about how applied research is best defined in vocational education and training (VET) contexts. The discussion will open at the Applied Research and Innovation Affinity Group workshop to be held at the World Federation of Colleges and Polytechnics (WFCP) World Congress in Melbourne in October 2018, and extend beyond the workshop through the use of technology.

A discussion about the definition of applied research in VET is timely. An agreed definition of applied research in VET can inform policy design and applied research practices within VET institutions and provide a foundation for applied research collaborations between Affinity Group members.

Applied research has proven in many countries to stimulate innovation in enterprises, especially micro and small to medium businesses (SMEs), and ongoing improvement and innovation in VET teaching practices. When actively engaged in applied research with local industries, VET colleges and institutes become integral to local innovation systems; not only through the generation of new and improved products, services and processes, but also through the supply of skilled, innovative and entrepreneurial graduates.

Much can be learned from countries that have strategically invested in applied research capability in VET and are reaping the economic and social benefits as a result.

However, the definition of applied research is a contentious issue in VET. We know applied research in VET is not the same as university-based research (Williams, 2013) and that it usually involves problem-solving activities (Beddie and Simon 2017, Luke 2013, TAFE NSW) for industry clients seeking a practical outcome such as a new or improved product, service or process. We also know it can involve teachers and students and is generally based on observable experience and empirical evidence. Much applied research in VET appears to be consistent with the OECD Frascati Manual's definition of applied research or experimental development (OECD, 2015) (see page 8). The pragmatic nature of these activities distinguishes them from basic (pure or fundamental research) which is about the advancement of knowledge rather than the pursuit of a specific use or commercial outcome of research, at least in the short term (Ibid.).

Case studies of applied research in VET selected from six countries – Canada, Australia, the United Kingdom, the Netherlands, Germany and New Zealand – suggest a broad range of research activities across a range of industries that differ according to their primary purpose. For example, while most case studies result in a new or improved product or process for an industry partner, others focus on involving students in applied research projects as a core part of their studies. It is sometimes difficult to distinguish in examples of applied research for industry if the activity is indeed applied research or experimental development (defined by the OECD as one possible stage of the product development process).

The discussion in this paper relates to applied research in publically funded VET institutions. It examines current definitions of applied research in VET and questions if they account for the applied research practices described in the case studies. Do they fit the breadth of industries served by VET such as the arts sector for example? Is the involvement of teachers and students in applied research be a defining characteristic? Does applied research in VET always produce new knowledge as the Frascati definition demands or are other definitions more suitable? Is applied research in VET a

scholarly activity related to teaching and learning? The exploration of these and other questions will assist in defining applied research in VET and what it means to be a VET scholar.

This paper is structured in four sections. The following section, Section 2, provides applied research policy and funding settings in the Australian, Canadian, United Kingdom (UK), European and New Zealand (NZ) VET systems as background to the case studies. Section 3 explores definitions of research and development (R&D) and innovation to determine key characteristics of applied research. Section 4 investigates how "applied" is currently understood in VET and draws on case studies to tease out characteristics that distinguish applied research in VET. The conclusion poses an alternative definition of applied research and innovation in VET for consideration by the Applied Research Affinity Group workshop.

## Background and context

Members of the WFCP Applied Research Affinity Group share the challenges of ensuring VET keeps pace with rapidly changing economies, technologies and workforce skills needs, particularly the capacity to innovate. Innovation is as a major driver of a country's economic competitiveness and capacity to tackle economic, environmental and social challenges (Innovation and Science Australia, 2017).

Some countries have recognised the potential contribution VET systems can make to innovation by strategically investing in building their capacity for applied research. VET's strong links with industry, and unique position at 'the nexus of knowledge generation and its application at work' (Beddie and Simon, 2017: 7), makes VET a prime candidate for the supply of responsive, outcome-oriented research and development (R&D) for industry, especially for micro and SMEs. These often represent the majority of businesses[1] and lag behind in R&D investment and innovation.

This paper has chosen case studies of applied research in VET from Canada, the Netherlands, Germany, the UK, New Zealand and Australia to inform the discussion. Each of these countries has tackled the issue of innovation and applied research in VET in different ways. The Canadian and Dutch governments for example have invested heavily in building applied research capacity in VET to stimulate commercial partnerships with SMEs, while the UK government has invested in building scholarship in the further education (FE) sector primarily to enhance teacher capability and student learning.

**Australia**

In 2015, the Australian Government launched the National Innovation and Science Agenda (NISA) to order to stimulate a more innovative economy. The NISA made the case for more applied, industry-driven research to improve innovation output, particularly new-to-market innovations and innovation collaborations between businesses (Commonwealth of Australia, 2017). However, applied research in VET was not a consideration in NISA's policy and funding settings, despite VET's close associations with the business sector, especially SMEs. Since the NISA, numerous commentators have called for a strategic approach to applied research in VET to maximise the sector's role in Australia's innovation system (Goedegebuure and Schubert, 2017, the

[1] For example 99.7% of Canadian firms are micro to SME (CICAN, 2017) as are 97.5 % of Australian businesses (Commonwealth of Australia, 2018)

Commonwealth Inquiry into innovation and creativity in the workforce, 2017, Innovation and Science Australia, 2017, TAFE Directors Australia, 2016 and the VTA, 2018).

Despite the lack of policy support, some of Australia's public VET institutions (TAFE institutes), notably those registered as higher education providers (HEPs), have established applied research centres and are developing research and scholarly capability in their VET and higher education (HE) teachers. Much of this activity is driven by the regulatory requirement to demonstrate scholarship as part of HEP registration and also by a keen interest in the success of applied research models in other countries such as Canada and Europe. While still in its infancy, applied research in TAFE is starting to yield impressive results for institutes and their industry partners as can be seen in a sample of applied research projects provided in Attachment A.

**Canada**

In contrast, Canadian colleges and institutes have access to $75 million (or 2.4%) of federal research funding for applied research with plans to increase this figure to $300 million (CICAN, 2017). The funding is provided by the Tri-Council College and Community Innovation (CCI) Program, established in 2008, for applied research collaborations between colleges and institutes and local enterprises and is supplemented by contributions made by enterprise partners. The program is administered by the Natural Sciences and Engineering Research Council, in collaboration with the Social Sciences and Humanities Research Council and the Canadian Institutes of Health Research (VTA, 2018) and covers technical, environmental and social applied research and innovation.

The CCI Program covers six grants: Innovation Enhancement (IE) Grants with industry partners, Applied Research and Development (ARD) Grants to assist companies to solve problems geared to business goals, Applied Research Tools and Instruments (ARTI) for the purchase of research equipment by colleges and institutes, Technology Access Centre (TAC)[2] Grants, Industrial Research Chairs for Colleges (IRCC) Grants and College-University Idea to Innovation (CU-I2I) to improve collaborations between colleges, universities and business (CICAN, 2015).

The outcomes of the Canadian government's investment are impressive. Many new products, services and solutions to business problems have been developed for a range of industries including agriculture, environmental science and technology, heath, information technologies, building technologies and manufacturing and social innovation in fields such as design and visual and performing arts, industrial relations and public safety. The applied research work of colleges and institutes has led to improved regional capacity for innovation and the development of 'innovation literacy' in college students involved in applied research projects (Luke, 2013). Canada's colleges and institutes now operate over 400 research centres and laboratories (including 30 Technology Access Centres) which provide expertise in over 1,000 areas of research specialisation for private sector firms; 85% of which are SMEs and micro-enterprises. A list of Canadian applied research projects in provided in Attachment B.

**Europe**

Goedegebuure and Schubert (2017) provide numerous examples of highly successful applied research institutions in Europe, most notably Universities of Applied Science (UAS) in the Netherlands. UAS are professional tertiary education institutions with an orientation to applied

[2] Technology Access Centres provide local industry with access to specialised technology, equipment and expertise to enhance productivity and innovation and also help businesses to connect with funding sources (Beddie and Simon, 2017: 27).

learning and applied research services for industry. They were established by the Dutch government to strengthen the relationship between teaching and research and improving knowledge exchange with industry. The overarching goal was to improving the innovative capacity of the Netherlands by delivering highly-skilled graduates and services needed by (regional) industry and the public sector (EU, 2016). Additional funding was later supplied to stimulate innovation in regional industries and applied research in national priority areas. UAS now play an important function within the Dutch innovation system with almost 4,600 companies involved in applied research projects since the program began in 2005 (Ibid.). Also in the Netherlands, Novel-T (Enschede) and Brainport (Eindhoven) are highly successful examples of innovation ecosystems that are engaging in collaborative pure and applied research activities involving universities, UAS and enterprises (Goedegebuure and Schubert, 2017).

Fachhochschulen (universities of applied sciences) in Germany are also professionally-orientated universities specialising in applied teaching and applied research, mostly in technological fields. Originally vocational engineering schools, Fraunhofer institutes are funded by the Federal Ministry for Education and Research, and by state, European Union and private sector funding, to undertake applied research with industry partners, especially SMEs, in order to commercialise new products and industrial processes. This investment has led to over 150 highly successful spin-off companies and the recognition of Fachhochschulen in Germany's innovation system.

The Fraunhofer-Gesellschaft is a group of 72 institutes and research units throughout Germany that collaborate on applied research projects in the fields of health and environment, security and protection, mobility and transport, production and supply of services and communication. Their primary mission is to perform contract research for German industry, especially SMEs. Examples of applied research projects can be found at https://www.fraunhofer.de/en/research/current-research.html

**New Zealand**

In New Zealand, Institute of Technology and Polytechnics (ITPs) are publicly funded tertiary education institutions providing VET and higher education and are required to undertake applied and technological research under the New Zealand Education Act (1989). A Polytechnic for example,

> *. . . is characterised by a wide diversity of continuing education, including vocational training, that contribute to the maintenance, and advancement, and dissemination of knowledge and expertise and promotes community learning,* ***and by research, particularly applied and technological research, that aids development*** *(Giles and Collins, 2016, emphasis in original).*

To support applied research in VET, the New Zealand Government introduced performance based research funds for the ITP sector to build capacity and ensure the research meets quality standards. In 2016, the ITP sector received over NZD$7 million from the National Performance Based Research Fund with most applied research activities relating to industry problems and innovation and an increasing focus on commercial research. For example, UNITEC Institute of Technology and an industry partner developed a disaster recovery product for SMEs in the Cybersecurity field which was released to market in June 2018.[3]

[3] https://www.unitec.ac.nz/research-and-enterprise/cybersecurity-research

**United Kingdom**

Like Australia, VET institutions in the United Kingdom are under-recognised as partners in innovation (Beddie and Simon, 2018) when compared with Canada and Europe. Most of the research activity in the FE sector in the UK has been concentrated on developing a culture of scholarship to improve teaching and learning practices in FE colleges delivering higher education. Drawing on Boyer's Model of Scholarship (see page 9), the Scholarship Project ran from 2015 to 2018 funded by the UK government and resulted in the development of a Scholarship Framework that captures the different forms of scholarship practiced in higher VET including student scholarly activity and community and employer engagement through applied research. Newcastle College for example has adopted the concept of a 'civic college' which actively contributes to the social, cultural and economic capital of the cities and region in which it resides by undertaking research projects for community bodies that do not have research capability that usually involve students (Eaton and Gower, 2015).

## What is applied research?

According to the OECD's Frascati Manual (2015: 28-29), applied research is one of three research and development (R&D) activities. The other two are basic research and experimental development. The overarching term R&D is defined as 'creative and systematic work' that aims to increase the stock of knowledge (including knowledge of humankind, culture and society) and devise new applications for available knowledge. R&D activities must meet five international standards:

1. Be aimed at new findings (novel),
2. Based on original, not obvious, concepts and hypotheses (creative),
3. Uncertain about the final outcome (uncertain),
4. Planned and budgeted (systematic), and
5. Lead to results that could be possibly reproduced (transferable and/or reproducible). (ibid.: 46).

Basic research is carried out for the advancement of knowledge; that is to acquire new knowledge about an underlying foundation of phenomena and observable facts usually without a specific use, application or commercial outcome in view in the short term (Ibid.: 50). In contrast, applied research and experimental development are highly pragmatic activities that seek to find practical uses for basic research and/or new methods to achieve specific objectives. Thus,

> *Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. . . Experimental development is systematic work that draws on the knowledge gained from research and practical experience and which produces additional knowledge directed to producing new products or processes or to improving existing products or processes (Ibid.).*

Whereas applied research gives operational form to ideas, experimental development (one possible stage in the product development process) tests generic knowledge for specific applications and generates new knowledge in the process (Ibid: 51-52). Both are orientated to the development end of R&D but are not product development which is classified in the Frascati Manual as non R&D.

Consistent with the Frascati Manual, the Australian Research Council (ARC) provides a generic description of research that includes discovery (basic), experimental and applied research:

> *Research is the creation of new knowledge and/or the use of existing knowledge in a new and creative way to generate new concepts, methodologies, inventions and understandings. This could include the synthesis and analysis of previous research to the extent that it is new and creative (ARC, 2018: 9).*

Definitions of applied research from different industries are also consistent with the Frascati Manual. For example, in the field of Psychology:

> *Applied research refers to scientific study and research that seeks to solve practical problems. This type of research plays an important role in solving everyday problems that often have an impact on life, work, health, and overall well-being. Applied research is used to find solutions to everyday problems, cure illness, and develop innovative technologies.*[4]

According to the Canadian Association of Research Administrators, applied research is,

> *. . . the application of knowledge, focused on the resolution of a problem or need (usually identified by industry or other organizations within the community) with the objective of delivering a satisfactory resolution or result. This is distinct from the 'basic' or 'discovery' research (and related timelines) associated with the university sector.*[5]

From these and other definitions of applied research across different industries and research bodies, we can determine common characteristics. In summary, applied research is generally:

- Directed towards finding an answer a specific question or problem or determining why something failed or succeeded or improving knowledge and understanding about how a recognized need or want may be met,
- Focused on how to solve a problem not why (Pelletier, 2015),
- Sets out to discover the practical applications and uses of theories, knowledge, and principles in work to order to solve real-world problems in a particular field (NRC, 2005),
- Original work that determines new methods to achieve specific and pre-determined objectives (Deakin University),
- Based on observable experience and empirical evidence,
- Is often client-driven, project-based and tied up with ownership of intellectual property, and
- Is linked with innovation, particularly in health, business, education and science-related fields such as technology, engineering and manufacturing, food production and environmental sciences, although this link is often not made explicit.

### What is innovation?

Given the close links with innovation inferred in definition of applied research, it might be useful to consider how innovation is defined. At its simplest, innovation is the process of putting novel ideas into practice (Commonwealth of Australia, 2017). According to the OECD's Oslo Manual (2005),

[4] https://www.verywellmind.com/what-is-applied-research-2794820
[5] https://cara-acaar.ca/CARAblog?path=&node=aug22-17

*Innovation is the implementation of a new or significantly improved product (good or service), or process, new marketing method, or a new organisational method in business practices, workplace organisation or external relations (OECD, 2005: 46).*

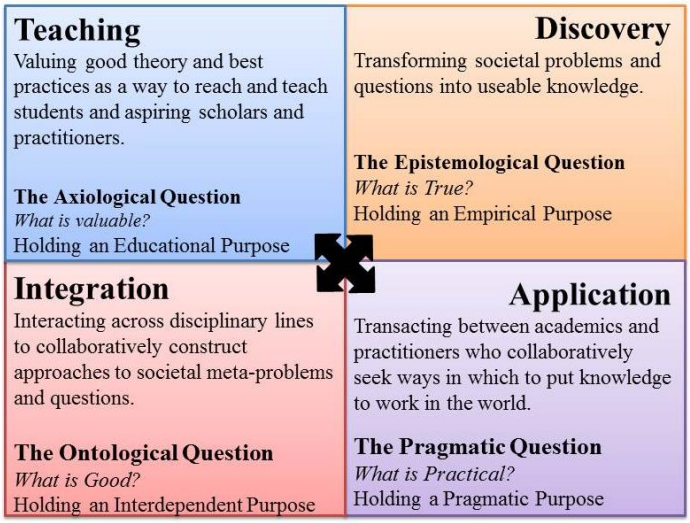
Innovation is commonly understood as a linear product development process that starts with scientific research at one end and ends with the production and commercialisation of new products, services and processes at the other.

However, alternative definitions of innovation in contexts such as education define innovation as networked practices that involve 'absorbing knowledge, applying it to new uses and creating new knowledge' in order to bring an idea to a desired outcome (Schuetze, 1999:1). Innovation is thus also understood as a knowledge producing practice as well as a product or service development/improvement process. It may be helpful to view both perspectives in VET contexts.

## What is applied research in education?

In higher education, applied research is often associated with Boyer's (1990) Scholarship of Application (Williams, 2013); one of four equally important scholarships in Boyer's scholarship model. Boyer's model has been widely adopted by universities around the world and increasingly by higher VET institutions such as TAFE HEPs in Australia and FE colleges delivering higher education in the UK. As captured in Caslin's (2014) representation (Figure I), the four scholarships are interrelated R&D practices with distinct purposes and outcomes.

*Figure I: Caslin's (2014) representation of Boyer's realms of scholarship*[6]




According to Boyer (1990: 21), the Scholarship of Discovery and the Scholarship of Integration reflect the 'investigative and synthesising traditions of academic life' and are associated with basic research. The Scholarship of Application (also known as the Scholarship of Engagement) however asks the questions, 'how can knowledge be responsibly applied to consequential problems and how can it be helpful to individuals as well as institutions' (ibid.). It brings theory and practice together in a specific field to produce new understandings about what research findings might mean in practice. The Scholarship of Teaching and Learning, also firmly embedded in everyday practice, is the

[6] Image obtained from the University of Phoenix https://research.phoenix.edu/mark-l-mccaslin/publication/scholarship-considered-generative-and-integral-synthesis-community

discipline of researching and reflecting on the best ways to enhance student learning using disciplinary and practice-based knowledge. The aim is to,

> *. . . stimulate active, not passive, learning and encourage students to be critical, creative thinkers, with the capacity to go on learning after their college days are over (Ibid: 24).*

## What is applied research in VET?

There are numerous definitions of applied research in VET in the literature. For example, in Australia, McDonald et al (1992: 9) define applied research in VET as two distinctive streams:

1. General issues-based - applied research that looks for principles or models that give an understanding of VET beyond specific contexts and has direct applications to educational policy and practice, and
2. Client-specific applied research - which looks for answers to a particular problem or new understanding VET in a specific context with little generalisability beyond that context.

According to the authors, the important characteristic of research in VET is not so much the type of research being utilised (is it basic, applied or experimental) as much as the fact that it involves the 'non-routine' application of knowledge.

More recent definitions reflect the growing interest in applied research partnerships with industry. For example in TAFE,

> *Applied research concentrates on technical challenges, business process bottlenecks and service delivery inefficiencies. It may also be concerned with designing high quality training programs that overcome such problems; including examining what constitutes best practice in teaching and learning. But it's the challenge, the bottleneck, the inefficiency; the idea in a business setting that is the flywheel of applied research (VTA, 2016: 2).*

TAFE NSW similarly defines applied research (in higher education in TAFE) as,

> *. . . research that sets out to solve a specific practical problem, understand it and communicate the solution. It is different to basic or pure research which is often designed to contribute to furthering knowledge about a particular issue. An applied research project will generally produce a substantial outcome, for example, a design, a tool, a process, a set of data or a technique. Products may also be tested in a commercial setting as part of a research project (TAFENSW, page 5).*

In these definitions, applied research is grounded in real industry contexts, problems and challenges. The motivation may be activated by an industry client for commercial outcomes or by VET practitioners seeking to solve a problem related to industry or teaching and learning practices.

In Canada, the primary orientation of applied research in VET leans to commercial product development, as Luke (2013: 37) explains:

> *Applied research is distinguished from basic research in that it is oriented almost exclusively toward commercialization and practical outputs, such as the development of prototypes and the market entry of new products and services.*

This approach is demonstrated in the Canadian case studies (Attachment B). In some cases, it is difficult to distinguish between applied research and experimental development as defined by the Frascati Manual. The Fraunhofer institutes in Germany similarly emphasize the commercial impact of applied research activities.

> *Fraunhofer is tackling the current challenges facing industry head on. Its lighthouse projects put the focus on strategic objectives with a view to developing practical solutions from which economies such as Germany's can benefit. The topics these projects address are geared towards economic requirements. By pooling their expertise and involving industrial partners at an early stage, the Fraunhofer Institutes involved in the projects aim to turn original scientific ideas into marketable products as quickly as possible.*[7]

Beddie & Simon (2017: 20) expand on the understanding of applied research in VET to include the participation of students in applied resrach projects as a learning activity:

> *Applied research in an educational setting is not only concerned with producing the outcome of increasing understanding or solving problems in industry; it might also contribute to pedagogy and to involving students in research activity, thereby extending their skills and producing the sort of creative workers the innovation system needs.*

The involvement of students and teachers in industry projects substantially improves their 'innovation literacy' (Luke, 2013) and the relevance and currency of VET teaching and teachers. According to TAFENSW, students gain the capability to 'to inquire and investigate, to recognise opportunities for change, to build skills to produce robust evidence, propose solutions and be open to new ideas'. In effect students and teachers become part of an R&D department for an enterprise (Goedegebuure and Schubert, 2017).

This approach has been widely adopted in Canada. For example at the Southern Alberta Institute of Technology's (SAIT) Applied Research and Innovation Services (ARIS) centre, students are involved in industry-based applied-research projects through practicum placements, capstone projects and as student research assistants. They,

> *. . . use their knowledge and skills to collaborate with ARIS researchers and industry partners, contributing their own innovative ideas to the technology-development challenges organizations are here to address.*[8]

In the UK, Blackpool and the Fylde College are using research-based learning for students studying the Foundation Degree in Human Biosciences. During their studies, students work with scientists to investigate new antibiotics from soil bacteria to tackle the challenge of increased antibiotic resistance in pathogenic bacteria. Research activities include practical soil sample collection, analysis of soil samples for antibiotic producing organisms and statistical analysis of soil microbe diversity.[9]

Some VET institutions make direct links between applied research and Boyer's Scholarship of Teaching and Learning. At William Angliss Institute, a TAFE HEP specialising in the Food, Hospitality and Tourism industries in Melbourne, for example,

[7] https://www.fraunhofer.de/en/research/lighthouse-projects-fraunhofer-initiatives.html
[8] https://www.sait.ca/applied-research-and-innovation-services
[9] https://www.aoc.co.uk/sites/default/files/Blackpool%20and%20the%20Flyde%20College%20-%20Human%20Biosciences%20programme.pdf

> *. . . staff undertake a broad range of scholarly activities in their specialised areas. They use this research to further engage with academic, industry and public communities via publications, seminars, events and association membership. They then use this new knowledge to further improve their teaching, thus enhancing our students' learning experience.*[10]

Williams (2013: 15) found that applied research in TAFE HEPs[11] often represents more than conventional definitions of applied research and in practice entails scholarly activity. For example, in the Viticulture industry:

> *Scholarly engagement is understood and practised in a holistic way, assimilating elements of discovery, integration and teaching in a partnership between academics, industry and undergraduate students. While it incorporates several customary elements, it turns them on their head. For instance, rather than the typical sequence of discovering knowledge then applying it, intellectual discovery, in the form of how flavours develop under certain conditions emanates from the practical work.*

As Williams (2013) notes, this is an unconventional coupling of Boyer's (1990) scholarship of engagement and the scholarship of teaching and learning that applies knowledge in a useful way. It involves,

> *. . . reflection and dialogue with others; in their sense-making, expert evaluation and professional judgement about input and feedback from engagement partners; in their capacity to synthesise that information with the literature, their own findings and expert knowledge; and in their capacity to articulate the synthesis of those knowledges in ways that allow others to benefit from, critique and build upon it (Williams, 2013: 35).*

The coupling of different types of scholarship is also occurring at Clarkson College in Nebraska, a college specialising in training or the health industries.

> *Applied Research focuses on the practical scholarship of integration and application. Professional practice benefits from the translation of original research to the global society, bringing life theory and reality to research . . . . The project may take on many forms. However, the common elements are translation of evidence to improve practice, processes and/or outcomes related to the research question, and to communicate their findings using appropriate technology.*[12]

## Towards an agreed definition of applied research in VET

While the list of definitions of applied research in VET provided above is not definitive, it highlights how the different ways applied research is interpreted and understood in VET and the complexities and challenges inherent in a single definition.

[10] William Angliss Website https://www.angliss.edu.au/about/research#
[11] Also known as mixed sector institutions defined as institutions that deliver VET and higher education with the majority of provision in VET.
[12] https://www.clarksoncollege.edu/default/assets/File/AppliedResearchManual-8-12.pdf

Case studies of applied research in VET affirm a wide range of applied research activities spanning problem-solving and product development for industry, the incorporation of knowledge and understanding into VET programs and practices and the use of applied research as pedagogy to develop innovation literacy in VET teachers and graduates. What distinguish these activities are their intended purpose and objectives and the non-routine and their highly practical application of knowledge.

If we look at the case studies more closely, we find they can demonstrate original work that brings research-based knowledge and practice-based knowledge together in creative and reflective ways (Nilsen and Ellstrom, 2012) to produce new and contextualised knowledge in specific industry contexts in some cases (Williams, 2013). While there are examples of pure or basic research (Jonas, 2013), most research activities in VET fit the definitions of applied research and experimental development as defined by Frascati or the Scholarship of Application and Scholarship of Teaching and Learning as defined by Boyer (1990).

In defining applied research in VET, we are in essence talking about practical research activities focussed on solving real-world problems to create new knowledge and/or use existing knowledge in new and creative ways (Beddie and Simon, 2018). We know it is not the same as university-based research (Williams, 2013), is not always product development, and is usually motivated by an industry problem. The problem is that much research in VET has not been named or claimed or published to the broader sector (Jonas, 2013).

We also know that applied research in VET drives innovation in industry, ongoing improvement in VET teaching and learning environments and VET's relevant to the labour market, notably teachers' industry currency and the innovation capabilities of graduates. The discussion from here needs to consider if definitions of applied research in VET adequately cover the range of industries that VET serves, if the links between applied research and knowledge building and applied research and innovation are predictable and that applied research in VET is defined to meet accepted standards and external scrutiny (Beddie and Simon, 2018). As Beddie and Simon write, 'Applied research in VET must embrace both the spirit of R&D, as reflected in the Frascati model and Boyer's four types of scholarship'.

A new definition will certainly assist in 'naming and claiming' (Jonas 2012) the types of research and scholarship currently underway in VET systems across the world. The following definition of applied research in VET is proposed for further debate.

> *Applied in research in VET is original investigation that sets out to solve technical and/or social problems related to industry, business or* ***student and/or teacher learning*** *for the purposes of innovation or the extension of knowledge in a specific related to a research question. It is original and systematic work that creates new knowledge or uses existing knowledge in new ways to achieve a practical aim or outcome that can be communicated with others in a discipline.*

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## Attachment A: Australian cases of applied research and innovation in VET

**Australia**

- The development of new forensic testing products by students through a partnership between Canberra Institute of Technology (CIT) and the Australian Federal Police.
- The development of a new product to monitor rainwater for a residential development in Victoria through a partnership between Holmesglen and South Easter Water Corporation in Victoria. https://holmesglen.edu.au/About-Us/Applied-Research-and-Innovation/
- The R&D facility at the Bendigo Kangan Institute (BKI) Textile and Fashion Hub that provides facilities and expertise for local micro and small businesses to prototype and test new products
- The international applied research collaboration between Holmesglen in Victoria, the University of Dundee in Scotland and the Dasman Diabetes Institute in Kuwait which is investigating the psychosocial impact of Type 1 Diabetes on children from birth to eight-years old https://holmesglen.edu.au/About-Us/Applied-Research-and-Innovation/
- The incorporation of applied research projects into each year of Melbourne Polytechnic's 3-year Bachelor of Agriculture and Technology. The case study describes the capture and use of carbon dioxide (CO2) from fermenting wine (Williams, 2013: 12),
- Applied research projects embedded in Holmesglen's Diploma of Laboratory Technology trialling DNA barcoding technology in Rural Victoria as part of a worldwide initiative to document and map living species https://holmesglen.edu.au/About-Us/Applied-Research-and-Innovation/
- Applied research collaborations between students from TAFE NSW Wagga Wagga and Charles Sturt University to develop a wireless sensor network kit to assist farmers to monitor sheep and water levels remotely as part of their studies. TAFE NSW Annual Report 2016-17. https://www.parliament.nsw.gov.au/la/papers/DBAssets/tabledpaper/webAttachments/72638/MIN%2017%20715%20Attach%20A%20Part%201%20TAFE%20NSW%202016-17%20Annual%20Report.pdf
- Collaboration between Santos Gladstone Liquefied Natural Gas (GLNG) and TAFE Queensland SkillsTech (TQST) to assist in optimising production systems, health and safety outcomes for workers and the impact of CSG operations on the environment and local communities.

## Attachment B: Canadian cases of applied research and innovation in VET

Case studies of applied research in Canadian colleges and institutes were obtained from CICAN's (2015) publication: The college and community innovation program, Partnerships for industry innovation and from the CICAN website.

**Environmental Science and Technology**

- George Brown College and the company Clear Blue Technologies partnered to develop, manufacture and test 20 prototypes of a manufacturing process to improve and scale the current manufacturability of solar and wind-powered systems. The research involved testing different versions of the product, and product and production testing processes (CICAN, 2015: 62).
- Using Drones for Aerial Mapping – Confederation College in Ontario undertook an applied research project in partnership with KBM Resources Group to compare the quality and accuracy of data acquired using unmanned aerial vehicles (UAV) or drones with data acquired through manned aircraft. The drones offer greater flexibility in capturing survey data, fly at a much lower altitude and thus can capture data below the cloud ceiling and are more cost effective for smaller scale jobs (CICAN, 2015: 2).
- Growing Microalgae for Biofuel – Nova Scotia Community College partnered with SabrTech Inc and Acadia University on an applied research projects related to the production of biofuel using green algae harvested from Nova Scotia shores. The research aimed to prototype and optimize production of algal biomass in real world settings and involved students from the college in microalgae cultivation and prototyping processes (Ibid.: 5).

**Manufacturing**

- Niagara College in Ontario partnered with a Bosch Rexroth; a company that specialises in industrial drive and control technologies to manufacture and install a hydraulic system at the Ontario Graphite mine site in remote Kearney, Ontario. The company did not have the means to obtain the precise measurements needed to manufacture the hydraulic system. The Advanced Manufacturing Innovation Centre at Niagara College used a 3D laser scanner to capture geometric and physical proportions of the machinery and developed the scan data for the mine and design information as the base for the hydraulic piping layout (Ibid.: 56).
- To assist aerospace manufacturing companies build new parts, Centennial College in Toronto partnered with Nexas Networks to design and prototype a new memory card for the computer numerical control (CNC) machines. These are high-tech sculpting machines that program the path of a cutting tool in core materials. Students worked on reverse-engineering the old card to produce a new, smaller and cheaper model with new features. The company now has plans to commercialize the product (Ibid.: 58).

**Renewable Energy and Conservation**

- Zero Emissions Public Transit – Red River College of Applied Arts, Science & Technology in Manitoba worked with Mitsubishi Heavy Industries and Manitoba Hydro developed a prototype of an all-electric zero-emissions transit bus and rapid charger system to suit Winnipeg's harsh winter conditions. The project has moved into production and field demonstration with four more buses now in service (Ibid.: 14).

- Nano-engineering for Better Smartphone Batteries – Lambton College in Ontario was granted an Applied Research Tools and Innovation grant to purchase highly-specialised laboratory equipment to develop the next generation of smart, cost-effective, nano-engineered materials for sustainable energy conversion and storage. The college worked with BioGenerator Energy Solutions and Toolrite to develop longer lasting, lighter weight, quicker charging, and higher-energy density lithium-ion batteries for smart phone and tablets (Ibid.: 34).

**Life Sciences and Health**

- Computerizing Homecare for Kidney Patients – Sault College in Ontario partnered with a small engineering company eQOL Inc to develop new technology for kidney dialysis at home. They developed a prototype of a microcontroller-based device to improve the connectivity of their eQ Connect™ technology that enables people living with chronic kidney conditions to manage self-care at home and reduce the number of visits to hospital (Ibid.: 24).
- New Technology Helps Asthma Patients Breathe Easy – SAIT Polytechnic in Alberta partnered with SolAeroMed to develop an innovation in asthma treatment. SolAeroMed has patented a drug, S-1226, that can overcome shortcomings in current medications for acute airway constriction. But the company needed SAIT's sports and wellness engineering technologies researchers to help develop a safe drug-delivery system to administer S-1226, which relies on compressed CO2 to open pathways in the lungs. The engineers designed and fabricated a prototype, producing a smaller and easy-to use alternative to its predecessor (Ibid.: 28).

**Agriculture and Food Technology**

- Biological Pest Control for B.C. Blueberries – An applied research project undertaken by Douglas College in British Colombia in partnership with the British Columbia Blueberry Council and Applied Bio-nomics Ltd. To investigate the control of agricultural insect pests in greenhouses, particularly the blueberry aphid, Ericaphis fimbriata. The applied research project tested the effectiveness of two possible insects to act as biological pest control agents (Ibid.: 34).

**Information and Communications Technology**

- GTA-based Lingo Inc. partnered with Seneca's School of Information and Communication Technology to develop a mobile app to support non-verbal individuals with severe speech-language impairments to communicate with others using a picture/written software system.

**Building Technology**

- Red River College of Applied Arts, Science and Technology in Manitoba partnered with Manitoba Hydro to investigate how air leakage affects a building's energy use, air quality, comfort and durability. A CCI Applied Research Tools and Instruments grant provided funding to purchase equipment to conduct tests in 26 buildings which helped to establish baseline air leakage rates and a practical air leakage testing protocol for building standards. Students were part of the research team (ibid.: 69).
- Algonquin College student researchers were key players in the design and testing of a new 3D radar system for an Ottawa security company, 3D Sentry Corp. The company develops perimeter surveillance for military bases, power stations, petrochemical plants and pipelines (Ibid.: 71).