CURRICULUM FRAMEWORK TRANSFORMATION TASKFORCE

EMBEDDING TRANSDISCIPLINARITY, INNOVATION AND ENTREPRENEURSHIP IN THE CURRICULUM: RECOMMENDATIONS

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The views contained in this document are 'point-in time' views of the Specialist Working Group and do not necessarily represent the views of Waipapa Taumata Rau | University of Auckland

Contents

1 Introduction

In the pursuit of academic excellence, *Taumata Teitei*, the Waipapa Taumata Rau | University of Auckland's strategic plan, emphasises the importance of complementing students' deep engagement in the discipline of their choice with additional knowledge and skills to enable them to be transdisciplinary, innovative and entrepreneurial in their thinking. Prepared in consultation with the Curriculum Framework (CF) Faculty and Specialist Leads, the Transdisciplinarity, Innovation and Entrepreneurship (TIE) Working Group (2021), the TIE Advisory Group (2022), as well as students and staff from various faculties throughout the University, this report provides key background and analysis in support of the proposed recommendations for integrating TIE into the curriculum and broader student experience at the Waipapa Taumata Rau | University of Auckland.

Based on our research and consultation, the TIE Specialist Leads recommend Waipapa Taumata Rau | University of Auckland:

- Require all undergraduate students to complete a minimum of 15 points of transdisciplinary coursework or research, which can be satisfied through a range of options that meet approved transdisciplinary learning outcomes.
- Integrate Innovation and Entrepreneurship knowledge, skills and competencies into all degree programmes at a level sufficient to satisfy the requirements of the Refreshed Graduate Profile.
- Develop new curricular and extra-curricular opportunities that:
    - foster inter- and transdisciplinary learning and research;
    - develop competencies and skills that enable transdisciplinarity, innovation and entrepreneurship;
    - promote inter-professional research and collaboration; and
    - engage with "wicked" or complex problems.
- Develop the Wicked Problems Challenge Series open to all undergraduate students.
- Increase Vertically Integrated Modules (VIM) and Vertically Integrated Project (VIP) offerings from outside a given discipline or area of enquiry for undergraduate students.
- Endorse student transcripts to signal extended study or research experience (45 points or more of scaffolded learning) in Transdisciplinarity and/or Innovation and Entrepreneurship.
- Develop cohort-based transdisciplinary and TIE postgraduate degree programmes.
- Create opportunities for students to participate in TIE research through development of a Research Opportunities Programme by offering funding and course credit for students who wish to gain research experience.

This report begins by laying the groundwork for emphasising TIE in the Waipapa Taumata Rau | University of Auckland curriculum, including their place in *Taumata Teitei*, key definitions, and scholarship on their use in higher education. The report then discusses the methodologies used and consultation processes we engaged in to form the proposed recommendations. Next the report provides high-level learning outcomes for transdisciplinarity and innovation and entrepreneurship, TIE combined competencies, and a menu of proposed curricular options to facilitate implementation of the TIE recommendations into the Waipapa Taumata Rau | University of Auckland curriculum, followed by several examples and explanations of certain curricular options.

2 Transdisciplinarity, Innovation, and Entrepreneurship as Discussed in *Taumata Teitei*

Taumata Teitei, the Waipapa Taumata Rau | University of Auckland's strategic plan, includes direct references to transdisciplinarity, innovation, and entrepreneurship in its key priorities for Education and Research. With respect to Education and the Student Experience, *Taumata Teitei* established a clear priority to provide:

> "Education that is research-informed, transdisciplinary, relevant and with impact for the world …"

and that develops students who are:

> "adept at broad and deep collaboration in transdisciplinary and cross-functional contexts, in and beyond the University, with an enduring commitment to impact and sustainability."

Taumata Teitei clearly established the importance of Innovation and Entrepreneurship in its Research and Innovation Priority 2, which asserts the vision that the Waipapa Taumata Rau | University of Auckland becomes "a global powerhouse of innovation, creativity and entrepreneurship" and will "instil an entrepreneurial mindset in our graduates".

3 Key Definitions

Through extensive research, internal discussion and external consultation, transdisciplinarity, innovation, and entrepreneurship have been defined in the following manner:

Transdisciplinarity iteratively interweaves knowledge systems, skills, methodologies, values, and fields of expertise

within

inclusive and innovative collaborations,

across

academic disciplines and outside academia,

to

develop transformative outcomes that respond to societal challenges.

In the Waipapa Taumata Rau | University of Auckland, Te Tiriti o Waitangi, kaupapa Māori, tikanga, Māori and Pacific knowledge systems, values and perspectives, inform and shape transdisciplinary activity

Innovation is the creation of knowledge and resources, or the new combination of existing knowledge and resources, to enable change.

Entrepreneurship is the capacity to engage with opportunities and ideas in order to create value with and for others. The attribution and creation of value is complex and diverse, such that the value created could exist in a number of realms, including social, cultural, economic or ecological.

4 Scholarship

This section provides a brief overview of and pertinent references to the scholarship on transdisciplinary and transdisciplinary education and innovation and entrepreneurship in education.

4.1 Scholarship on Transdisciplinarity and Transdisciplinary Education

With respect to Transdisciplinarity, the goals set out in *Taumata Teitei* align with best practices in higher education worldwide. The value of transdisciplinarity in research and teaching has been established in the academic literature and methods have refined through arduous academic critique. International scholarship regards transdisciplinary approaches as critical for addressing complex societal issues (Blackstock and Carter, 2007; Funtowicz and Ravetz, 1993; Gibbons et al. 1994; Lawrence, 2010; Nowotny et al. 2001; Robinson 2008; Talwar et al. 2011; Schneider et al., 2019; Wiek et al. 2012; 2014). Nonetheless, engaging in transdisciplinary contexts remains challenging and requires new mindsets and approaches for responding to complex societal challenges (Darbellay, 2014; Hasson & Polk, 2018; Polk, 2014).

Trandisciplinarity, as a concept, gained prominence through 'Mode 2 thinking' in the early 1990s (Gibbons et al., 1994), which called for a transformation in knowledge production that was transdisciplinary, hetergeneous, and heterarchical to address the increasing complexity of societal issues, particularly environmental problems. This form of knowledge production proved more "socially robust" due to its joint production of knowledge with societal stakeholders by including local and other forms of knowledge in decision-making (Gibbons, 1999). Recent advances in approaches to transdisciplinarity (e.g., Maasen & Dickel, 2019) focus on the process of knowledge production to ensure this is open, engaged, inclusive, responsible, collaborative, goal-oriented and aligned with stakeholder perceptions, values and interests.

Transdisciplinary educational experiences are seen as a complement to, not a replacement for, strong disciplinary education. Given recognition of the need for non-linear approaches that transcend disciplinary and academic boundaries to address the many complex societal issues we currently face and the prominence of transdisciplinary understanding in research, the need for opportunities for transdisciplinary teaching and learning in higher education are essential (Budwig and Alexander, 2021; Carroll et al. 2014).

4.2 Scholarship on Innovation and Entrepreneurship Education

Achieving the objective in *Taumata Teitei* for Waipapa Taumata Rau |University of Auckland to become "a global powerhouse of innovation, creativity, and entrepreneurship" requires that we "instil an entrepreneurial mindset in our graduates" (p.6.). This mindset and the skills and competencies underpinning it are essential to respond innovatively to complex social and environmental challenges. Entrepreneurship education has become a significant field of study over the past two decades (Larios-Hernandez et al., 2022). It is now common to incorporate opportunities to develop the skills and competencies for innovation and entrepreneurship (sometimes called enterprising) across degree programmes. Many countries have national frameworks for this.

A substantial literature on entrepreneurship education demonstrates the benefits for students, universities and society (European Commission, 2015). For example, students may increase their self-efficacy (Schøtt, et al., 2015; Sánchez, 2013; Oosterbeek, et al., 2010), employability, academic performance and the potential to start an enterprise (European Commission, 2015); universities benefit from increased student engagement, retention, motivation, community relationships and enhanced

reputation; and society benefits through improved sustainability, social inclusion, innovation, and economic growth.

The New Zealand Global University Entrepreneurial Spirit Student Survey (GUESSS) compares Waipapa Taumata Rau | University of Auckland students' responses with a global sample from more than 2900 universities in 57 countries (Yun and McNaughton, 2021). Among the respondents, 79.1% had yet to take an entrepreneurship course, the lowest rate among the countries included in the survey. However, our students who have taken an entrepreneurship course evaluate their entrepreneurial learning outcomes higher than the average for the global sample, possibly reflecting the effectiveness of our approach to innovation and entrepreneurship curricular integration. But – we need to expand our activities to reach more students.

Several well-developed frameworks identify the skills and competencies associated with entrepreneurship or enterprising (e.g., McCallum et al., 2018, QAA; 2018). One of the most complete is EntreComp adopted by the European Union and comprises three competence areas: ideas and opportunities, resources, and into action, with each area containing five competencies. Together, these make up the 15 competencies individuals can use to discover and act upon opportunities and ideas. For each competency, the framework describes learning outcomes for four maturity levels. Entrecomp incorporates innovation and creativity as competencies. This reflects that entrepreneurship education is primarily about an opportunity orientation and the perspectives and skills to solve problems, improve situations, and identify interventions in the social, commercial, governmental, environmental, and other contexts. There are many resources and tools available to spark thinking about how to integrate these competencies across all disciplines.

The interaction between transdisciplinarity and entrepreneurship is just beginning to be explored. As highlighted in this report, there is considerable overlap in the relevant competencies. There is also overlap with the other *Taumata Teitei* "hallmark elements" of sustainability and work-integrated learning. This is particularly evident at the nexus of innovation, entrepreneurship and sustainability (e.g., Lans et al., 2014). Vertically integrated research projects (VIPs), suggested later in this report to provide transdisciplinary experiences, have also been used to develop innovation and entrepreneurship skills and competencies (Strachan et al., 2019). For example, VIPs are one of the ways that St. Andrews University is implementing the 'Entrepreneurial St Andrews' pillar of its new strategic plan. Finally, Innovation and entrepreneurship skills and competencies also contribute to work-integrated learning, as they are also essential employability skills.

5 The TIE Journey and Methodology

The content of this report reflects the efforts and contributions of numerous individuals and groups over the last year, including the TIE Working Group (2021), the TIE Specialist Leads (2022), the TIE Advisory Committee (2022), and the Curriculum Framework Transformation (CFT) Taskforce (2021-2022).

TIE Working Group Members 2021: Nicholas Rowe (Lead)

Kristiann Allen (Koi Tu), Kelly Burrowes (ABI), Angus Campbell (CAI), Paul Corballis (Science), Lina El Jahel (B&E), Jamie Gillen (Arts), Susan Kemp (EDSW), Jaime King (Law), Jan Lindsay (Science), Marie McEntee (Science), Sue McGlashan (FMHS), Rod McNaughton (CIE, B&E), Peter Rachor (B&E), Peter Shand (CAI), Karl Stol (Eng.), Yvonne Underhill-Sem (Arts), Mark Vickers (Liggins), Michael Witbrock (Science), Student Representative: Jasmine 'Ofamo'oni

TIE Specialist Leads (2022): Jaime King (Law) and Marie McEntee (Science).

TIE Advisory Group (2022): Kristiann Allen (Koi Tu), Priyanka Dhopade (Eng.), Lina Jahel (B&E), Susan Kemp (EDSW), Sue McGlashen (FMHS), Rod McNaughton (CIE, B&E), Peter Rachor (B&E). Student Representatives: Alofa So'olefai, Jasmine 'Ofamo'oni.

The TIE Working Group (2021) began by consulting the academic literature related to TIE to gain an improved understanding of the state-of-the-art in these fields, as well as the policies and practices related to TIE in world-class universities. The TIE Working Group identified and evaluated a range of TIE initiatives and considered how those initiatives might be integrated into both the University's undergraduate and postgraduate curricula. The TIE Specialist Leads and the TIE Advisory Group (2022) extended this work and analysed in greater depth a set of distinct initiatives. As part of that process, we requested, received, and reviewed information from each faculty regarding their current transdisciplinary offerings to survey the current scope and substance of transdisciplinary curricula at the University. In addition to analysing current and potential initiatives within the CFT Faculty and Specialist Leads Group, we also held several meetings to elicit feedback from staff, students, and University leadership, including presenting our ideas in staff and student webinars and consultation sessions, before PDDC, and in one-on-one consultations with various staff, student, and community members.

5.1 TIE at Waipapa Taumata Rau | University of Auckland

As part of our work, we aimed to define and describe transdisciplinarity in a way that captured the unique context in which it would be taught at Waipapa Taumata Rau | University of Auckland. Three principles guided our work.

First, the TIE Working Group felt it was essential to include a statement that clarified that - in the context of Aotearoa and the Waipapa Taumata Rau | University of Auckland - Te Tiriti o Waitangi, kaupapa Māori, tikanga, Māori and Pacific knowledge systems, values and perspectives must inform and shape transdisciplinary activity.

Second, the TIE Working Group recognised that effective transdisciplinary approaches arise from strong disciplinary foundations. This does not require, however, that a student must have completed all or most of their disciplinary education before being exposed to the benefits of transdisciplinarity and developing the skills and competencies necessary to participate in transdisciplinary initiatives. Quite the contrary, we have heard from several staff and students in our consultations a view, which is likewise supported in the literature, that exposure to transdisciplinary knowledge and skills early in the tertiary educational experience can help students develop a transdisciplinary mindset in ways that complement and supplement their disciplinary study (Sharp et al., 2021).

Third, beyond disciplinarity, transdisciplinarity differs from multidisciplinarity because it requires cross-disciplinary engagement and collaboration, and it differs from interdisciplinarity because it requires collaboration with members of the community to co-create methods to bring about transformative societal change (Fazey et al., 2019; Schneider et al., 2019; Wilbek et al., 2022). These principles helped define the contours of our proposals for transdisciplinary study.

6 Learning Outcomes and Competencies for TIE

As a result of our research, deliberations, and consultations, we have developed the initial phases of a proposed framework for including TIE in the curriculum, including high-level learning outcomes and competencies.

6.1 High-level Transdisciplinary Learning Outcomes

To develop the skills, knowledge and attitudes to engage in transdisciplinary activity, so that graduates understand, at a foundational level, the context and value of using transdisciplinary approaches to respond to complex societal issues, and are prepared, at a foundational level, to collaborate with others in transdisciplinary activities.

Further Learning Outcomes:

- To differentiate transdisciplinary approaches from other forms of disciplinarity and the appropriate contexts for their use.
- To identify the types of problems that may be addressed by transdisciplinary approaches.
- To develop skills and competencies needed for engaging in a transdisciplinary approach.

6.2 High-Level Innovation and Entrepreneurship Learning Outcome

To develop the knowledge, skills and attitudes to be entrepreneurial, so that graduates are prepared, at a foundational level, to discover and act upon opportunities and ideas for transformation into social, cultural, or financial value for themselves and others.

6.3 TIE Competencies

While the concepts of Transdisciplinarity, Innovation, and Entrepreneurship are distinct, significant overlap exists between them, especially in the key competencies and skills, indicating that curricular and extra-curricular opportunities could be created that would stimulate student development in all three areas (Figure 1).

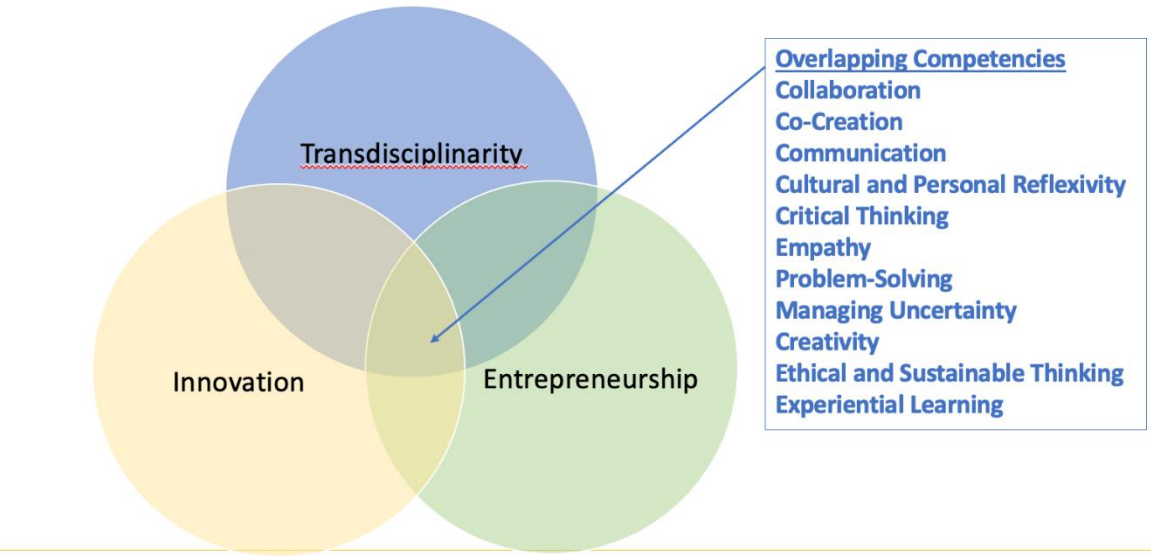


Figure 1: Transdisciplinarity, Innovation and Entrepreneurship Overlapping Competencies
(Source: J King & M McEntee)

As a result, we aim to align learning opportunities and experiences across TIE as much as possible to facilitate coordination of course delivery and skill development. While such alignment will often be possible, some deviation will occur. Not all Transdisciplinary courses will have Innovation and Entrepreneurship elements, and likewise not all Innovation and Entrepreneurship courses and offerings will qualify as Transdisciplinary.

7 Transdisciplinarity, Innovation and Entrepreneurship Curriculum Recommendations

To align with *Taumata Teitei,* we recommend the following changes to the curriculum with respect to TIE.

7.1 At Undergraduate Level

7.1.1 Transdisciplinary Requirement

We recommend that all Waipapa Taumata Rau | University of Auckland undergraduate students satisfy a 15-point Transdisciplinary Requirement. This proposed requirement could be met through a range of coursework and research options that meet the Transdisciplinary learning outcomes at a foundational level to develop basic Transdisciplinary awareness and skills. (See Section. 8 and Appendix 1).

7.1.2 Integrate Innovation and Entrepreneurship into the Degree Programmes

We recommend integrating innovation and entrepreneurship skills and competencies into all degree programmes at a level sufficient to satisfy the requirements of the Refreshed Graduate Profile. We provide numerous options for ways to integrate innovation and entrepreneurship pedagogy into Transdisciplinary offerings in Section 8. Furthermore, different methods for integrating Innovation and Entrepreneurship knowledge, skills and competencies into courses and degree programmes are discussed in Section 8.4 below.

7.1.3 Develop New Curricular, Co-curricular and Extracurricular TIE Opportunities

To support the recommendations above and provide flexibility, we recommend the development of an array of new curricular and co-curricular and extracurricular opportunities that:

- foster inter- and transdisciplinary learning and research;
- develop competencies and skills that enable Transdisciplinarity /TIE;
- promote inter-professional research and collaboration; and
- engage with ‘wicked’ or complex problems.

These new curricular, co-curricular and extracurricular opportunities could be housed within faculties, large-scale research institutes (LSRIs), and/or research centres, and could include new Transdisciplinary /TIE courses, modules, majors, degree programmes, and research opportunities. (See below, Section 7.3).

Staff should be encouraged and supported to develop these new curricular and extra-curricular opportunities.

7.1.3.1 Develop a Wicked Problems Challenge Series

All undergraduate students should have the opportunity to participate in the Wicked Problems Challenge Series, described in depth below, which would bring together staff and students from diverse disciplines and faculties to respond to a particular 'wicked' or complex problem. Wicked problems are "characterised by their complex integrated social, cultural, economic, political, as well as environmental dimensions" (Sharp et al, 2021, p.621). This complexity makes them resistant to being solved (Turnbull and Hoppe, 2019). Many, but not all, Wicked Problems Challenges will enable students to expand their knowledge, skills and competencies related to sustainability, innovation and entrepreneurship. These classes will offer relational, cohort-based learning and provide a strong shared experience for many students. Furthermore, the Wicked Problems Challenge Series courses can serve as a starting point for related study modules, such as Vertically Integrated Modules (VIM), or research-led initiatives, such as Transdisciplinary Vertically Integrated Projects (TVIPs), or form part of the recommendation for a 45-point out-of-discipline study option.

7.1.3.2 Develop new Transdisciplinary /TIE vertically integrated modules and vertically integrated project offerings

The University should encourage and support staff to develop an array of new Transdisciplinary /TIE VIMs and VIPs (described in Section 8). These optional advanced offerings, which can begin with and build off a particular Wicked Problem Challenge, can amount to 45 points of out-of-discipline study and enable students to engage in scaffolded learning or research activities in a particular area of interest.

7.1.4 Transcript Endorsement of Extended Study Options in Transdisciplinarity and/or Innovation and Entrepreneurship

Students should have the option to have their transcripts endorsed to signal extended study or research experience of 45 points or more in Transdisciplinarity and/or Innovation and Entrepreneurship. This could include 45 points of participation in a VIP, vertically integrated module or other combination of courses and experiences.

7.2 At Postgraduate Level

Transdisciplinary offerings are optional at postgraduate level. However, we recommend the development of cohort-based transdisciplinary and TIE postgraduate degree programmes and a range of TIE course and research offerings for postgraduate students.

7.3 Transdisciplinary /TIE Curriculum Options

To implement the vision of *Taumata Teitei*, we have identified a suite of Transdisciplinary /TIE curricular options that will offer a broad spectrum of Transdisciplinary /TIE learning opportunities and experiences across the University. Development of a suite of options offers flexibility to students, staff and degree programmes with respect to how to incorporate the requirement into degrees, while still delivering on the scope and rigour of TIE learning envisioned in *Taumata Teitei*.

The Matrix below (Table 1) provides an overview of the suite of Transdisciplinary /TIE options that could be developed within the curriculum at the University. Each of the options listed is described in more detail in Appendix 1, and several are described in the examples below.

Table 1: Suite of Transdisciplinary (TD) /TIE opportunities
(Source: J King & M McEntee)

	Transdisciplinary (TD) Requirement *(equivalent to 15 points if satisfies TD learning outcomes)*	**Transdisciplinary Experience** (in isolation do not qualify as 15 points for TD requirement but could be combined with other options to meet TD Requirements)	**Transdisciplinary (TD) Extended Study (Endorsed)** *(equivalent to 45 points if satisfies TD learning outcomes)*
Undergraduate	• Wicked Problem Challenge Series • TD/TIE Course • Vertical Core with TD/TIE Components • TD/TIE Research Project • TD/TIE Capstone • TD/TIE Research (attached to LSRI or Faculty)	• Extra Curricula Experience (e.g. Velocity) • Capstone with TD/TIE components • WIL/CIL Experience	• TD/TIE Vertically integrated Projects (VIP) • TD/TIE Vertically Integrated Modules (VIM) • TD/TIE dedicated - Vertically Integrated Core • Combination of Transdisciplinary Courses & Experiences
Proposed Optional Postgraduate Offerings			
	• Postgrad TD/TIE Course • VIP* • TD/TIE Research (with LSRI or Faculty)*	• Extra Curricula Experience (e.g. Velocity)* • WIL/CIL Experience*	• TD/TIE Cohort Degree Programmes (PhD, Masters, PGDip, Grad Certs) • Degrees in Transdisciplinarity (PhD, Masters)

*Non-course postgraduate options (suitable for research students)

7.4 Supplementary note on Governance

The TIE Specialist Leads note the development of transdisciplinary curriculum opportunities, integration of Transdisciplinarity into the curriculum, and tracking completion of the proposed Transdisciplinary requirement would benefit from the establishment of a governance entity. This entity could work collaboratively with other entities that provide cross-campus curricular offerings in areas where there are natural synergies, such as Innovation & Entrepreneurship, Sustainability, and Work- and Community-Integrated Learning (WIL, CIL). Similar entities exist at other universities to support and help implement Transdisciplinary learning and research. Key benefits that such an entity could provide include:

- Connect staff to enable collaboration in course development and implementation; connect students by facilitating transdisciplinary experiences and connect staff in experiences like VIPs;
- Provide staff support to reinforce and strengthen their capability in transdisciplinary teaching;
- Provide teaching resources to support transdisciplinary learning in courses and the development of universal resources that could be available for staff to supplement in their existing courses (however the latter in isolation would not be sufficient to meet the 15-point transdisciplinary requirement);
- Ensure that transdisciplinary learning outcomes are met in course design, implementation and assessment.

8 Examples of Potential Transdisciplinary /TIE Offerings

This section outlines potential examples to provide clarity and structure to some of the recommended learning opportunities.

8.1 Example: Wicked Problem Challenge Series

This proposed new initiative seeks to promote inter-faculty collaboration in teaching and enable a large number of students to experience transdisciplinary contexts.

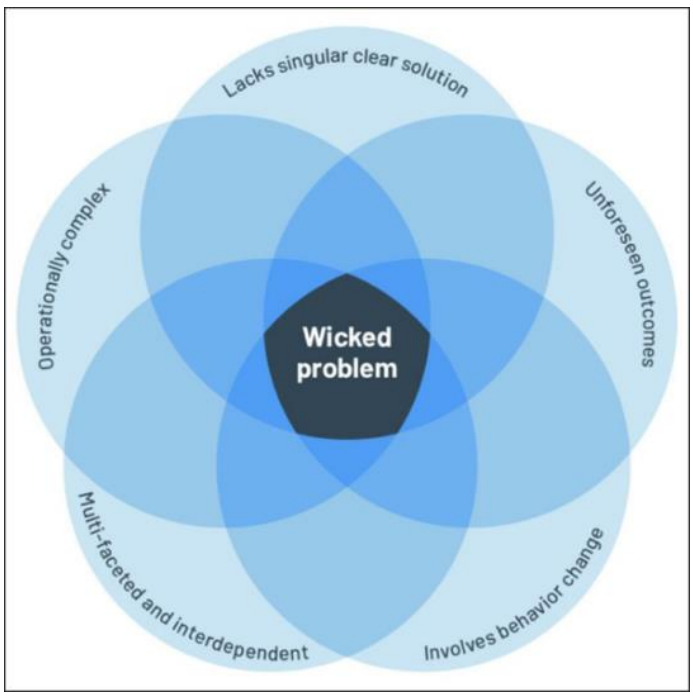


Figure 2: Characteristics of Wicked Problems.[1]

The Wicked Problem Challenge Series is proposed as a first year offering at undergraduate level that would meet the 15-point Transdisciplinary Requirement. However, students could enrol in a Wicked Problem Challenge at any year in their undergraduate study.

Indeed, from a transdisciplinary perspective, mixed year cohorts offer excellent opportunities for students to collaborate with others from differing backgrounds, degrees and levels of disciplinary maturity.

The Wicked Problem Challenge Series is not designed to tackle the technical or social complexities of wicked problems but rather to enable students to understand the contexts of wicked problems, particularly their social contexts and how people engage and collaborate to address such problems in these contexts. Learning is therefore focused on the development of a transdisciplinary mindset instead of solving wicked problems, which by their very nature cannot be solved. Disciplinary knowledge may contribute to discussions, but the wicked problem acts more as the context for the collaboration and the development of a mindset. As such, all year levels will gain value from this learning.

[1] See https://www.intapp.com/blog_posts/tackling-wicked-problem-firm-leadership-continued-success-conundrum-part-1/

8.1.1 Scaling the Wicked Problem Challenge Series

Table 3 provides an example scenario whereby 5000 students seek to enrol in the Wicked Problems Challenge Series. For 5000 students, we propose there would need to be a minimum of ten Challenges.

Table 2: Managing Student Numbers in a Wicked Problem Challenge.
(Source: M McEntee & J King)

EACH CHALLENGE 500 students	10 Challenges (each student enrols in one). Challenge options could be added and deleted each semester depending on what faculties and staff propose, and according to staff availability. Students could also suggest options for Challenges. Given the nature of wicked problems, a number of Challenge options would have either a sustainability or an innovation and entrepreneurship focus, or have strong components of these specialties embedded in them.
HUB 100 students	Each Challenge has FIVE Wicked Problem Hubs (each student chooses one wicked problem) The 500 Challenge students are presented with five wicked problem options. They choose one and form a Wicked Problem Hub with 100 students.
LAB 25 students	Each Wicked Problem Hub has FOUR Provocations (student chooses one provocation and joins the Wicked Problem Lab working in teams of five) Each student in the Hub is presented with FOUR provocations and the student chooses one they wish to explore. They form a Wicked Problem Lab with 25 students in each lab.

We now present this as a specific example.

8.1.2 Example of ONE Challenge

Our 5000 students are presented with ten Challenge options (see Figure 3). A particular student chooses the Biosecurity Challenge and joins 500 students in this Challenge.

Figure 3: Wicked Problems Challenge Series: Possible Challenges (Source: M McEntee & J King)

The students in the Biosecurity Challenge are then presented with five Wicked Problems (Figure 4). Each student chooses ONE wicked problem to form a Wicked Problem Hub. Each Hub houses 100 students.

Figure 4: Proposed Biosecurity Challenge: Wicked Problem Choices (Source: M McEntee)

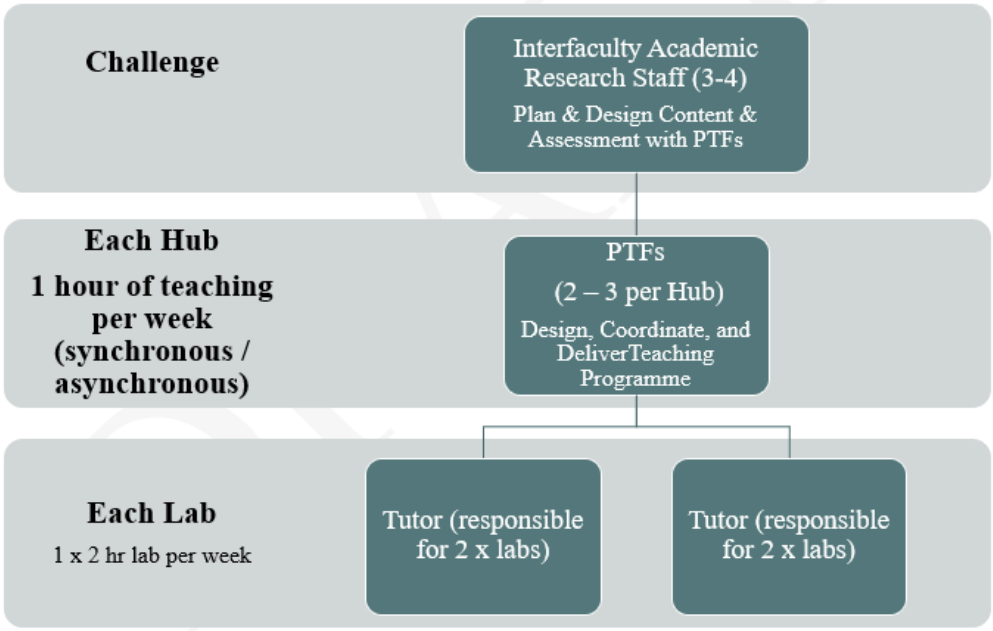
Imagine the student chooses 'Addressing Kauri Dieback' as their Wicked Problem and joins the Wicked Problem Kauri Dieback Hub. The students in the Kauri Dieback Hub are then presented with four provocations (Figure 5), from which they must choose ONE provocation. Each student then enters a Wicked Problem Lab focused on that provocation along with 25 other students.

Figure 5: Four Possible Provactions in the Wicked Problem Kauri Dieback Hub. (Source: M McEntee)

8.1.3 Staffing and Teaching Commitment

The staffing and teaching commitment for the Biosecurity Challenge example, outlined above, is described in Table 4. This is indicative only and would differ across Challenges. The staff to student ratio in the Labs would be approximately 1:25.

Table 3: Potential Staffing and Teaching Commitment for Biosecutity Challenge Example.
(Source: M McEntree)



8.2 Example: Vertically Integrated Projects

Vertically Integrated Projects (VIPs) enable undergraduate and postgraduate students to participate in long-term staff-led research projects over multiple years, providing them with valuable research experience and skills training. Students can participate in a VIP for course credit or in some instances for pay or a stipend. VIPs offer undergraduate students a unique opportunity to experience hands-on research that can prepare them for and assist in their transition to postgraduate research programmes. By developing robust VIP opportunities, the Waipapa Taumata Rau | University of Auckland can join the VIP Consortium, a rapidly growing group of over 40 leading international universities worldwide that have integrated VIPs into their curriculum.

Led by an interdisciplinary staff team, Transdisciplinary /TIE-focused VIPs (TVIPs) will enhance students' abilities to develop TIE skills and competencies and use them in research and problem-solving. While participating in a TVIP, undergraduate students will collaborate with a small team of other students on aspects of the research project that are appropriate for their knowledge and skill level, under the supervision of postgraduate students and staff. Throughout the project, students will both give and receive feedback, receive mentorship and serve as mentors, and develop a range of skills associated with working on a transdisciplinary and multi-level team. All participants in the TVIP will contribute to the iterative evolution of the research project, as well as the structure and function of the TVIP itself, allowing the model to improve over time. Furthermore, TVIPs offer relational learning opportunities that can last

the length of a student's degree, creating strong networks of students, staff, and community members that extend across disciplines and beyond the University.

8.2.1 Sustainable Societies: How Transportation Policy Affects Health Outcomes

To gain a better sense of how a TVIP might function, imagine a broad TVIP focused on Sustainable Societies that includes multiple sub-projects. One sub-project could be: How Transportation Policy Affects Health Outcomes. The research team could include inter-faculty staff and students from Urban Planning and Design, Population Health, Environmental Sciences, Law, Geography, Business and Economics, Māori Studies, Engineering, Sociology, and Psychology, just to name a few.

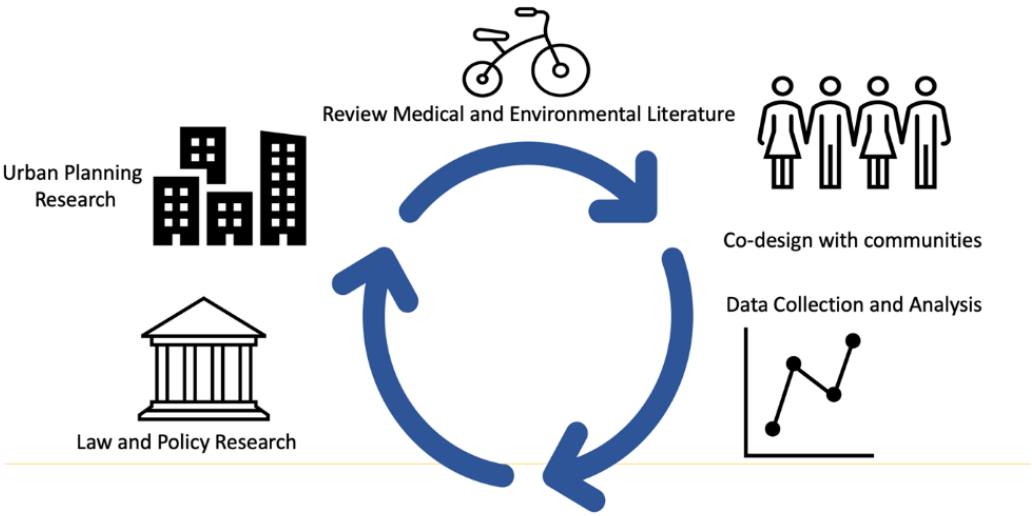
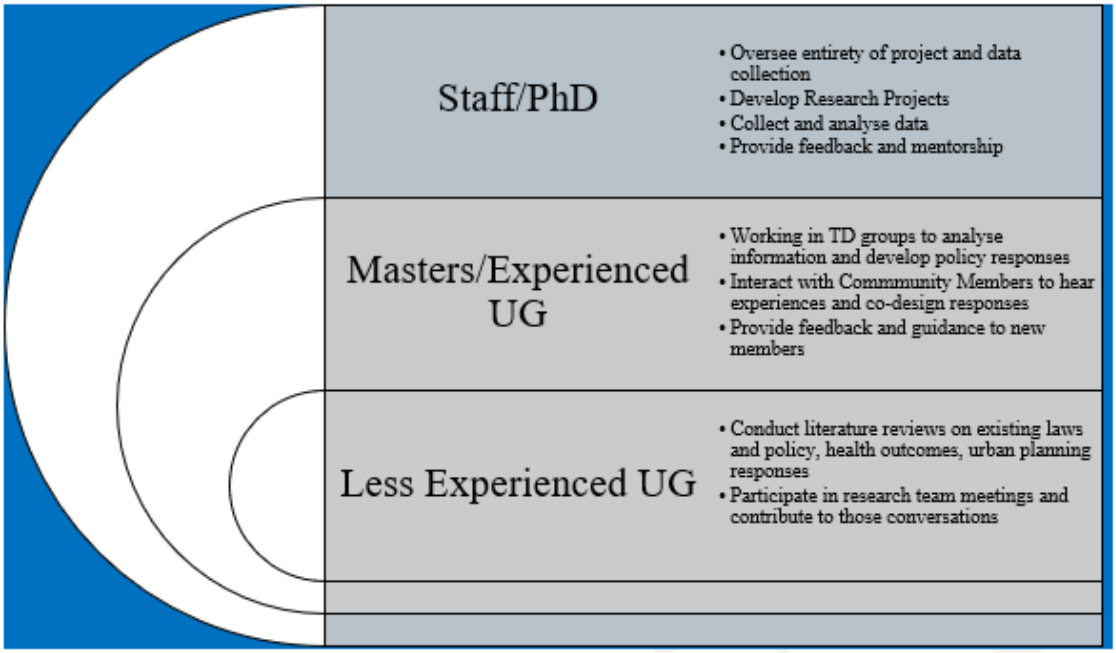


Figure 6: Example VIP
(Source J King)

Students participating in this sub-project could engage in research tasks suitable for their knowledge and skill level, which they would then feed back into the larger team for transdisciplinary analysis and development of recommendations. The kinds of tasks that students at different levels may perform are listed in Table 5.

Table 4: Staff / Student Responsibilities in a TVIP
(Source J King)



Each semester, students would work on interdisciplinary teams to produce a work product which could take a variety of formats that are suitable for the project, its intended audience, and the TVIP team members involved. On the Transportation and Health project, work products might include a policy brief, a hui with community members to discuss potential community responses to a transportation challenge, an academic paper, or an innovative transportation proposal.

Overall, developing a robust set of VIP offerings will enable students to develop and strengthen their TIE competencies and skills, create a sense of belonging to a cohort of students and staff from across the University, enhance student pathways to research, and promote transdisciplinary research.

8.3 Example: Transdisciplinary /TIE Vertically Integrated Module (TVIM)

If an undergraduate student wished to complete more than 15 points in transdisciplinary learning and have Transdisciplinarity or TIE endorsed on their transcript, they would need to complete 45 points of Transdisciplinary /TIE study over three semesters or years. The 45-point 'out-of-discipline' study option recommended as part of the CFT would provide an avenue to facilitate this.

Endorsement of transdisciplinary or TIE study could be achieved through a Transdisciplinary /TIE Vertically Integrated Module involving scaffolded learning over semesters.

An example of a current TVIM which achieves TIE learning through scaffolded learning is the following example from the 'Science in Society' Module which is offered currently through the Faculty of Science to a wide cohort of students from inside and outside science, with mixed year levels studying together in all courses.

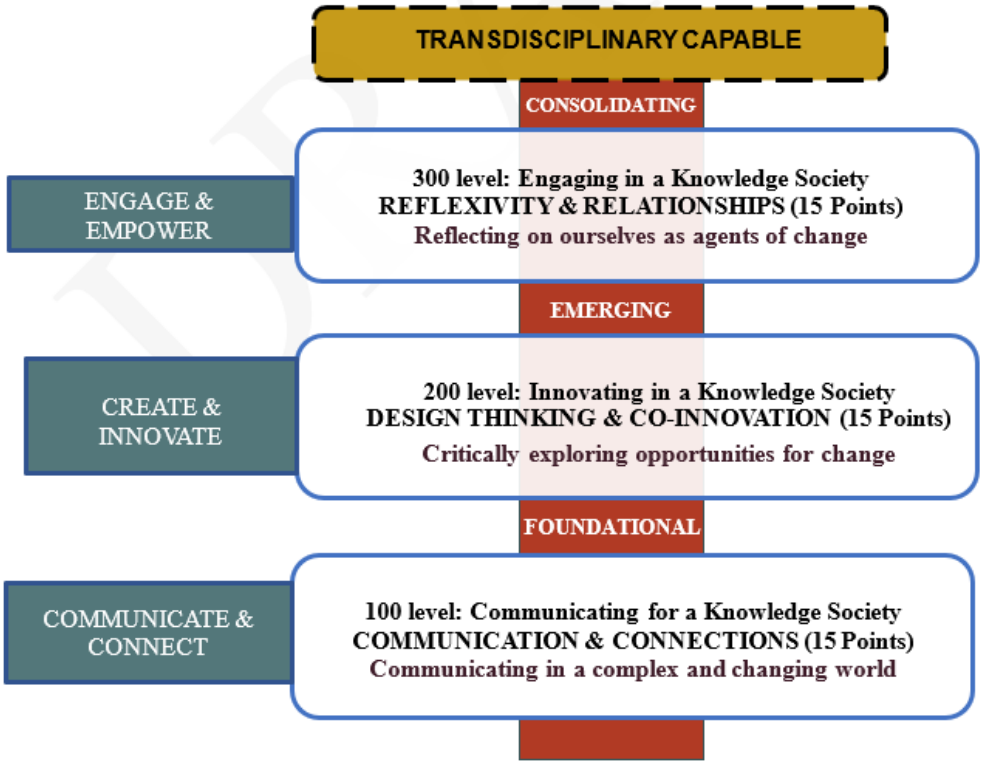


Figure 7: TVIM Example: Waipapa Taumata Rau | University of Auckland Science in Society Module
(Source: M McEntee)

This module is not presented as a framework for all TVIMs, but rather as an example of what a TVIM might look like. The 'Science in Society' TVIM is a TIE module as it has explicit innovation and entrepreneurship learning outcomes at stage 2 and 3 levels.

At 100 level, students learn to communicate and connect in a changing and complex world.

At 200 level, students explore opportunities for change by learning how to create and innovate in responding to complex problems.

At 300 level, students reflect on themselves as agents of change by engaging with communities beyond the University.

Together, this scaffolded learning enables a student to deepen their transdisciplinary knowledge and skills, forming the foundation for postgraduate transdisciplinary study.

8.4 Ways to Integrate Innovation and Entrepreneurship into the Curriculum

Whether integrated within a transdisciplinary context, a more specific disciplinary or a more application-oriented course, Innovation and Entrepreneurship (I & E) pedagogy provides a lens for students to consider challenges in many realms and on various scales. This I & E knowledge, combined with the associated mindset and skillsets, enhance learning, application, and retention in existing and new courses across subjects and levels. Innovation- and entrepreneurship-based pedagogies offer important perspectives on problem-based learning that encourage students to look beyond their discipline, engage in systems thinking, and de-construct important issues. Students combine critical thinking with process and methodology to navigate the ambiguity and risk in proposing and evaluating pathways to improvements and interventions.

The descriptions below, drawn from the donor-supported Hynds Curricula Initiative at the University of Auckland, provide apt examples of how innovation and entrepreneurship knowledge, skills and competencies can be integrated into new and existing programmes as part of assessments, courses, vertical modules, and core courses to introduce students to innovation and entrepreneurship in a language and context that are familiar and resonate with them.

FMHS PHARMACY 412, Pharmacy 5 is a 45-point course that leverages I & E pedagogy as part of the Integrated Project assignment. Students work in teams to consider how to develop initiatives that can be delivered via community pharmacies to serve patients in high-need District Health Boards. Student initiatives have included diabetes screening, fitness counselling, vaccine clinics, and neo-natal health screening.

CAREER 100: Crafting Your Career is a course that enables Arts and other students to use User Centred Innovation methodology and the power of their own agency to develop solutions to various real-world product and programme challenges in partnership with business and community organisations. As part of a broader consulting team focused on developing improvements and solutions, the course helps many Arts students consider how to apply their disciplinary knowledge to create and communicate important perspectives and values.

SCIGEN 201: Innovation in a Knowledge Society is part of the SCIGEN Vertically Integrated Module, discussed above, that is delivered through a partnership between Faculty of Science and UABS to students from a wide range of Science disciplines, along with others from across the University. The course helps students balance important environmental, social, and technological challenges and integrate diverse knowledge systems, social science, innovation theory, and best practice problem-solving approaches.

ENGGEN 303: Managing Projects and Innovation and ENGGEN 403: Managing A Business Case, "Systems" form part of the ENGGEN Innovation-based core courses, which are compulsory for all Engineering students, drawn from eight majors within the Faculty. In ENGGEN 303, students participate as a team in the semester-long Sustainable Innovation Project, choosing a focus area, and creating an Opportunity Assessment and Business Case for their commercial, social, or governmental innovation. ENGGEN 403 builds upon the Innovation foundations to consider a "wicked problem" facing New Zealand, culminating in the week-long team-based 40 hour Systems Project. Recent topics have included reduction of methane agricultural emissions in North Canterbury, a means of achieving increased capacity for Waitemata Harbour crossing, and the impacts and trade-offs of "doughnut economics" to traditional measures of Productivity and GDP growth.

These examples serve as excellent starting points for ways to integrate Innovation and Entrepreneurship into a variety of degree programmes and the creation of new courses and modules.

9 Recommendations

In light of the above, the TIE Specialist Leads Team recommends that Waipapa Taumata Rau | University of Auckland should:

- Require all undergraduate degrees to complete a minimum of 15 points of transdisciplinary coursework or research.
    - Students may fulfil the Transdisciplinary requirement through a range of teaching and research options that meet approved transdisciplinary learning outcomes (discussed above and listed in Appendix 1).
- Integrate Innovation and Entrepreneurship skills and competencies into all degree programmes at a level sufficient to satisfy the requirements of the graduate profile.
- Develop new curricular, co-curricular and extracurricular opportunities that: 1) foster inter- and transdisciplinary learning and research; 2) develop competencies and skills that enable transdisciplinarity, innovation and entrepreneurship; 3) promote inter-professional research and collaboration; and 4) engage with "wicked" or complex problems.
    - Staff should be encouraged and supported to develop these new curricular, co-curricular and extracurricular opportunities, which could include new Transdisciplinary/TIE courses, modules, majors, degree programmes, and research opportunities.
    - These new curricular, co-curricular and extracurricular opportunities could be housed within faculties, LSRIs, and/or research centres.

- Develop the Wicked Problems Challenge Series open to all undergraduate students.
    - Many, but not all, Wicked Problems Challenges will engage with knowledge, skills, and competencies related to sustainability, and/or innovation and entrepreneurship.
    - These classes provide a strong shared experience for students and a starting point for related study modules, such as Vertically Integrated Modules (VIMs), or research-led initiatives, such as Transdisciplinary Vertically Integrated Projects (TVIPs).
    - These classes may form part of the recommendation for a 45-point out- of-discipline study option.
- Increase opportunities to engage in Transdisciplinary/TIE VIMs and VIPs from outside a given discipline or area of enquiry for undergraduate students.
- Endorse student transcripts to signal extended study or research experience (45points or more of scaffolded learning) in Transdisciplinarity and/or Innovation and Entrepreneurship.
    - This would allow students to signal extended training in Transdisciplinary or Innovation and Entrepreneurship coursework or research activities, such as participation in a VIP, VIM or other combination of courses and experiences.
- Develop cohort-based transdisciplinary and TIE postgraduate degree programmes.

- Create opportunities for students to participate in T, I or E research through development of a Research Opportunities Programme by offering funding and course credit for students who wish to gain research experience.

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11 Appendix 1. Menu of Options for Embedding Transdisciplinarity

Option	Description
Wicked Problem Challenge Series	15-point courses designed to be appropriate for Year 1, but could be taken at any time during a programme of study. These courses could be offered in both semesters, and as intensives or summer offerings. This seminar series will offer Waipapa Taumata Rau | University of Auckland students the opportunity to develop skills necessary for transdisciplinary engagement in small cohorts by studying different facets of some of the most complex, challenging, and important problems of our time. Such skills include collaboration, reflection, iteration, appropriate use of scientific data and evidence, critical thinking and analysis, and communication. Potential broad topics include: Sustainable Societies, Indigenous Rights and Responsibilities, Inequality, Democracy, Biodiversity, The Future of Health, and 21st Century Education. These seminars can serve as an entry point for VIPs, VIMs and a Transdisciplinarity endorsement.
Transdisciplinary Course	15-point course at any level and taken at any time during a programme of study. These courses could be offered in both semesters, and as intensives or summer offerings. These courses could be developed as a transdisciplinary course, teaching transdisciplinarity and providing relevant contexts (chosen by the teaching team) to enable students to engage in transdisciplinary contexts. The courses would likely be taught by inter-faculty staff and would enrol interdisciplinary students.
Transdisciplinary/TIE Vertically Integrated Module	45 points. Normally, but not exclusively, 15 points each year over three years and normally, but not exclusively, has offerings at Stage 1, 2, 3 to facilitate scaffolded learning. All courses would be developed as transdisciplinary TIE courses, teaching Transdisciplinary/TIE competencies and providing relevant content/experiences (chosen by the teaching team) to enable students to engage in Transdisciplinary /TIE contexts. The courses would likely be taught by inter-faculty staff and would enrol interdisciplinary students.
Transdisciplinary /TIE Vertical Core	45 points. Normally, but not exclusively, 15 points each year over three years and normally, but not exclusively, has offerings at Stage 1, 2, 3 to facilitate scaffolded learning. All courses would be developed as transdisciplinary courses, teaching transdisciplinarity and providing relevant Transdisciplinary content/ experiences (chosen by the teaching team) to enable students to engage in transdisciplinary contexts. The Transdisciplinary core could be offered within a degree programme and could be an alternative to current degree vertical cores. The Transdisciplinary Vertical Core would likely have an

	inter-faculty course design and teaching team and would enrol interdisciplinary students.
Transdisciplinary/TIE Vertically Integrated Project	15 points for participation in a VIP per semester. Ideally, taken in three or more consecutive terms or years to enable continuity within the project and scaffolded learning. VIPs offer undergraduate and postgraduate students the opportunity to participate in an ongoing research project with staff and students at different levels of study over an extended period of time. Principal investigators of transdisciplinary VIPs would be able to enrol students from different disciplines into research projects, enabling them to meet the requirement for transdisciplinary awareness. If a student participates in a transdisciplinary VIP for multiple years or in combination with other TIE offerings, they may achieve an Endorsement of Transdisciplinarity or Innovation and Entrepreneurship or other acknowledgement on their transcript.
Transdisciplinary/TIE Research (with LSRI or Faculty)	Points will vary depending on the amount of transdisciplinary exposure and time spent in transdisciplinary activities. Students may obtain transdisciplinary credit arising from participating in a transdisciplinary/TIE research project that enabled the student to develop transdisciplinary problem-solving skills in a collaborative and interdisciplinary environment. Transdisciplinary research projects could be housed in LSRIs, research centres, or the faculties. Such an experience can build upon transdisciplinary awareness toward an Endorsement in Transdisciplinarity or Innovation and Entrepreneurship.
Transdisciplinary/TIE Capstone	15 point course at Stage 3 level. These courses could be offered in both semesters, and summer offerings. Students from any faculty could take this as their programme's capstone requirement, so long as it sufficiently related to their degree. The course would be developed as a transdisciplinary course, teaching transdisciplinarity and providing relevant content/experiences (chosen by the teaching team) to enable students to engage in and learn how to use the knowledge of their discipline in a transdisciplinary context. Would likely have an inter-faculty course design and teaching team.
Vertical Cores with Transdisciplinary Components	Existing cores in degree programmes could insert Transdisciplinary components/modules in core courses in ways that meet Transdisciplinary /TIE learning outcomes to provide opportunities for students to engage in transdisciplinary contexts over consecutive years. These modules would require interdisciplinary cohorts and Transdisciplinary /TIE experiences. Each year's module on their own would not satisfy the 15pt Transdisciplinary requirement, but over consecutive years, the student engagement in the modules in each course would enable a student to meet the Transdisciplinary requirement.

Capstone with Transdisciplinary Component Does not on its own satisfy the Transdisciplinary 15 point requirement but could be taken with other options (Transdisciplinary/TIE experiences) to qualify.	Existing capstone in disciplinary programme of study that would insert a Transdisciplinary component/section in their course to provide opportunities for students to engage in transdisciplinary contexts and develop Transdisciplinary skills.
Transdisciplinary /TIE Work- and Community-Integrated Learning Experience	Points will vary depending on the amount of transdisciplinary exposure and time spent in transdisciplinary activities. Students may obtain transdisciplinary credit arising from a Work-Integrated or Community-Integrated Learning experience that allowed them to engage and collaborate with individuals in transdisciplinary problem-solving or develop other transdisciplinary skills. Such an experience can build upon transdisciplinary awareness toward Distinction in Transdisciplinary.
Co-curricular Activity Does not on its own satisfy the Transdisciplinary 15-point requirement but could be taken with other options (Transdisciplinary/TIE experiences) to qualify.	Provides opportunities for students to engage in co-curricular transdisciplinary contexts such as community engagement, velocity experience, or make-a-space engagement.
Degree Programmes in Transdisciplinarity	N.B. Offered only as named Transdisciplinary degree at postgraduate level. Degrees can be: Degrees in Transdisciplinarity - exploring and contributing to the scholarship of transdisciplinarity (Masters or PhD) Degrees in Transdisciplinary/TIE Subject Matter - Inter-faculty initiative (PhD or Masters) with named PhD or Masters in subject matter. This would involve students studying transdisciplinary contexts or issues across multiple facilities. Students work in cohorts with cohort lecturers for the first half and then with their own research supervisors (inter-faculty) in the second half–meeting with others in their cohort throughout.