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Recognising and valuing Māori innovation in the high-tech sector: a capacity approach

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ABSTRACT

This paper explores what it takes to develop a common language and shared sense of purpose between Māori and the high-tech science sector. Robotics and automation, 3-D printing, sensors, and digital technologies are shaping New Zealand's economy in fundamental ways. If, as envisioned under New Zealand's Vision Mātauranga policy, Māori contribution to economic growth through distinctive Indigenous innovation is to be recognised and valued, then *how* this happens in these frontier science domains requires investigation. Findings are presented from the first phase of a longitudinal study of one National Science Challenge: Science for Technological Innovation (SfTI) – Kia Kotahi Mai, Te Ao Pūtaiao me te Ao Hangarau. Collecting a variety of data from science, business and Māori participants, the findings suggest that while there is enabling macro policy, organisational and science team human and relational capacities require recalibrating. The authors outline a model of how this can be done through a focus on mātauranga (knowledge), tikanga (practice) and kaupapa (focus areas) and how SfTI is reshaping its organisational practice to align to this model. The research also identifies the important role of the science intermediary as crucial to this alignment within teams.

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Introduction

Since 2014, New Zealand has developed a new funding approach to how it tackles the country's science-based issues. Scientists and communities have been brought together to work collaboratively across disciplines, institutions and borders to address challenges such as climate change, aging populations, environmental security, and the impacts of technology on society (Ministry of Business Innovation and Employment, n.d.). However, unsurprisingly, working across interdisciplinary and institutional borders as is

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envisioned by New Zealand's 11 National Science Challenges (NSCs) is difficult (Carlile 2002; Garud et al. 2011; Hsiao et al. 2012). Heterogeneous groups – researchers, policy-makers, stakeholders, funders, and Māori – have to find a common language and sense of purpose so that everyday ideas and science ideas can be bridged (Kuhlmann and Rip 2014; Efstathiou 2016). This requires change and shift at all levels of the science system, from the policy and funding level, to the science organisation and individual researcher level.

Māori are explicitly included in the National Science Challenges through the Vision Mātauranga (VM) science investment policy that seeks to 'unlock the innovation potential of Māori knowledge, resources and people to assist New Zealanders to create a better future' (Ministry of Research, Science and Technology 2007). While the VM policy has been in place for a number of years, there is no template on how to bring Māori issues (kaupapa), processes (tikanga) and knowledge (mātauranga) into rapidly developing high-tech domains. Such domains – robotics and automation, 3-D printing, sensors, and digital technologies – are shaping New Zealand's economy in fundamental ways. If, as envisioned under the VM policy, Māori contribution to New Zealand's economic growth through distinctive Indigenous innovation, is to be recognised and valued, then *how* this is to happen in these frontier domains requires investigation.

Such an investigation is the basis of the case study presented in this paper of one of these collaborative science challenges: Science for Technological Innovation (SfTI)-Kia Kotahi Mai te Ao Pūtaiao me te Ao Hangarau. Launched in 2015, SfTI is a 10-year, $100 million programme charged with growing a high-tech New Zealand economy via physical sciences and engineering. Within the SfTI challenge sits a longitudinal project, 'Building New Zealand's innovation capacity' (BNZIC), where researchers are investigating whether the concept of open innovation (Chesbrough 2003), the idea that commercial enterprises create market value through exploitation of external sources of knowledge, can be applied more systematically across the physical sciences and engineering landscape. To exploit knowledge to bring products or services into use, enterprises – and in the case of New Zealand's science sector, research teams – need to connect with others. In turn, this is dependent on their absorptive capacity (Cohen and Levinthal 1990) and ability to recognise, connect to and assimilate sources of new external knowledge for commercial opportunity. How, why and when research teams connect to Māori knowledge and with Māori organisations for commercial or other purposes is a key investigation area for the BNZIC project, with a focus on understanding both the organisational and individual relationships and capacities necessary for such partnerships. By focussing on these capacities, we posit that a common language and shared sense of purpose can be developed, however, it requires a systematic and fine-grained approach at multiple levels.

This paper presents findings from the first three and a half years of research. We used a mixed methodology to collect a variety of data across seven large and over 30 small projects involving almost 300 participants. Our data sources included observations of science teams' formal and informal meetings, focus group discussions and individual interviews, surveys of businesses and examination of primary and secondary material.

We present our findings as follows. In the second section, we provide a contextual overview of the Vision Mātauranga policy and the trends that gave rise to and now maintain the policy as a norm in New Zealand science policy. We pay particular attention to Indigenous and Māori thinking in relation to systems of knowledge or mātauranga and

science. This leads into section three where we provide background to the SfTI challenge's aims, examining the concept of absorptive capacity. We review the concept's applicability to Māori knowledge, relationships and interests in light of our analysis in the opening section. In section four, we provide detail about our methodology, while in section five, we move to the meso-level processes that have been developed to implement VM into SfTI organisational practice. In the sixth section, we examine the micro-level of individuals and teams. In particular, we characterise scientists' initial attitudes towards VM and then take a 'deep dive' into one project, analysing the important role of the Māori intermediary. We conclude our study by reviewing our key insights and suggesting future research directions.

The Vision Mātauranga policy

Vision Mātauranga has been described as an internationally unique and valuable strategy that positions 'indigenous people, knowledge and resources, as a source of opportunity and potential national benefit in research, science and technology' (Ministry of Research, Science and Technology 2009, p. 2). While the strategy may be valuable, a template for implementation has been missing, with 'those who enact those policies [failing] to recognise and examine the assumptions, concepts and norms within which they operate' (Moewaka Barnes 2006, p. 2). In this second section, we unpick the macro assumptions, concepts and norms that gave rise to the VM policy, which we see as a convergence of a number of distinct and contradictory trends.

First, the post-colonial Indigenous rights movement that manifested in New Zealand in the sovereignty protests of the 1960s and 1970s (Erueti 2017), led to the formation in 1975 of the Waitangi Tribunal. Despite a long history of Māori Treaty activism, it was not until the 1970s that there was sufficient political will to address Māori demands (Catalinic 2004). Through its deliberations, the Tribunal developed Treaty principles such as active protection of *taonga* (treasures), partnership, the duty to consult, the right to development, and the recognition of self-determination (Byrnes 2006). These principles found their way into various government policies including Vision Mātauranga which, while not directly referencing the Treaty of Waitangi were implicitly referenced in the four themes of Indigenous Innovation, Taiao (environmental sustainability), Hauora/Oranga (health and wellbeing), and Mātauranga (Indigenous knowledge) (Ministry of Research, Science and Technology 2009).

The Indigenous rights movement also drew attention to a second trend: that of the growing assertion of Indigenous and non-Western science as a knowledge system with a long history of contribution to its own and broader science traditions (The International Council for Science 2002). Indigenous and post-colonial science scholars (Agrawal 1995; Durie 2004; Posey 2004) have noted that Western scientific knowledge 'is *not* the 'sum of all knowledge'' (Tsosie 1999, p. 619) but is one of many types of knowledge. Despite the ethnocentrism that has construed Indigenous knowledge as pseudo – or unscientific or an artefact of a former life (Bielawski 1990, p. 18; Scott 2011), Indigenous knowledge has adapted to European technology, while maintaining its frame of reference (Pool 2015). Such understandings have been reflected in international conventions and declarations such as the Declaration on the Rights of Indigenous People (United Nations 2007) and the Convention on Biological Diversity (United Nations 1992).

Māori likewise have asserted the value of drawing from traditional knowledge frameworks. Such knowledge (mātauranga) provides a complex frame of reference for understanding the world (Cram et al. 2002). Based on principles of whanaungatanga (kinship), mātauranga organises and relates things in the world to each other through whakapapa (kin relations) in a way that organises knowledge itself (Waitangi Tribunal 2011). As an epistemology, it has its own sets of theories, practices and protocols and modes of rigorous inquiry (Broadhead and Howard 2011; Smith et al. 2016), and thus it is possible to see similarities to other formal knowledge systems (Hardy and Patterson 2012). However, mātauranga is more than a research paradigm. Mātauranga has a core ethical and values base (Barlow 1993; Mead 2003), not least of which are obligations of kaitiakitanga (protection) at the community level to people, environments, stories and knowledge. Such knowledge can be viewed as a taonga (treasure) that must be protected for future generations (Waitangi Tribunal 2011, p. 85). Nonetheless, when combined with other knowledge systems at the research interface, it has the ability to contribute innovative and future-orientated solutions 'not possible by recourse to one system only' (Durie 2004, p. 11).

Ironically, positioning Indigenous knowledge as innovative has the effect of dovetailing mātauranga into a neo-liberal discourse that sees science as a primarily economic mechanism to support innovation, enterprise and exporting (Peters 2000; McCormack 2011). Framing Māori people, resources and knowledge as a source of opportunity fits a progressive market view (Bargh and Otter 2009), aligned to another policy approach – the capability approach (Humpage 2005) – that positions Māori as having 'the capability, initiative and aspiration to make choices for themselves' (Barcham 2012). From one perspective, the alignment of Māori development, self-determination and choice, can be seen as fitting not only the neo-liberal agenda, but also as a 'dangerous conversion of neo-colonialism and indigenous knowledge' (Smith et al. 2016, p. 141). On the other hand, framing Māori as capable of making their own decisions by including Māori aspirations in science policy may offer a chance to suture Māori approaches into the science system. Hence, there is a tension in the Vision Mātauranga policy between the neo-liberal economisation of science that also potentially co-opts mātauranga in a continuation of a colonial agenda, versus a more liberating and self-determining approach that sees the potential of mātauranga to open up the broader science system and thereby create synergies that benefit both Māori and the nation.

To conclude, the above analysis has shown that the various political, scientific and economic trends have combined so that Māori knowledge inclusion has become the norm in science policy. This shift has emerged as the views of the legitimacy of Māori claims within broader society and within science have changed. While this may now be the new norm, we began this section by noting that there is no VM implementation method within the science sector broadly, and specifically, within the new high-tech arenas that are the subject of this study. Rather, how to implement VM into science research has been case by case, with the Science for Technological Innovation challenge no exception. What, then, is the SfTI approach and how is it addressing assumptions, concepts and norms at the meso and micro levels? Moreover, by addressing these assumptions, are researchers and Māori developing a common language and shared sense of purpose?

To answer these questions, we now turn to our case study to examine how, by focusing on processes, relationships and knowledge with Māori partners, the Science for Technological Innovation challenge has sought to align the heterogeneous motivations, experiences and habits of Māori and scientists. To begin, though, we outline the SfTI challenge, its objectives, and the theoretical concepts that have underpinned its activities.

Shaping practice – SfTI's vision Mātauranga capacity approach

SfTI, like all of New Zealand's NSCs, is a virtual organisation that involves collaborators across many institutions, disciplines, and communities of practice (Scarbrough et al. 2015). Its mission – to enhance the capacity of New Zealand to use physical and engineering sciences for economic growth – is enacted through seven large 'spearhead' science projects and over 30 'seed' projects, in the areas of materials manufacturing and design; sensors, robotics and automation; and, data science and digital technologies. SfTI has been charged with inducing behavioural change across science, business and Māori spheres, essential in an environment where shifts in science and innovation are rapid and open (Chesbrough 2003; Fecher and Friesike 2014).

New Zealand researchers are highly productive as measured by publications and citations, but there is comparatively low business uptake of R&D (Ministry of Business, Innovation and Employment 2018). Despite this, New Zealand research has shown that firms with an innovation culture can create greater value and outperform competitors (Gibb and Haar 2010). More recently, it has been found that those New Zealand firms with stronger innovation cultures who can also draw on high levels of absorptive capacity – the ability of a firm 'to recognize the value of new external knowledge, assimilate it, and apply it to commercial ends' (Cohen and Levinthal 1990, p. 128) – in conjunction with skilled human resources may be able to achieve superior innovation performance (Haar et al. 2018). This latter SfTI survey of New Zealand businesses indicated that only a quarter had R&D partners but those with higher numbers of R&D relationships were positively related to innovation performance (Haar et al. 2018). Hence, SfTI's mission is to create not only cutting-edge science, but also to induce broader R&D science changes 'upstream' at the research conception phase, or 'mid-stream', when the technical complexities are certain enough that commercialisation is possible but open-ended (Fisher et al. 2006). Developing the attitudes, understandings and capabilities to seek out and engage in new R&D relationships, including with Māori, is key if innovative science ideas are to be brought into firms (Chesbrough and Brunswicker 2014).

However, collaboration for innovation is inherently difficult, with the norms of science, business and Māori different. To account for and then address these differences absorptive capacity has been redefined from the science perspective to identify the components that then can be turned into a programme to more closely align science to business and Māori. As can be seen in Figure 1, capacity has been split into three parts: technical, human and relational.

Technical capacity is defined as the ability to deliver 'stretch' or 'frontier' science and technology. As shown by the large circle, typically this has been the main or overriding consideration of the science sector. However, to engage successfully with non-technical others, scientists need to pay equal attention to other capacities. Thus, scientists need to build understandings and abilities – *human capacity* – that can communicate research

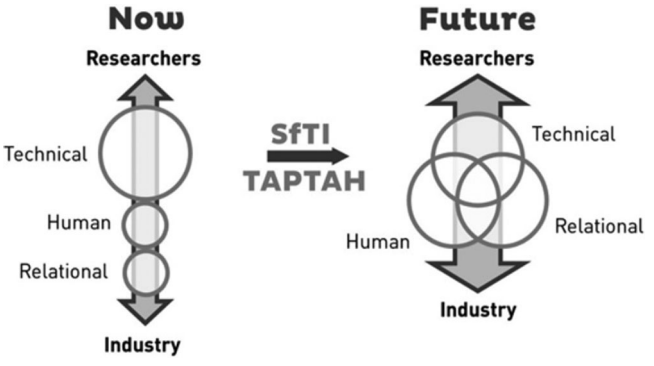

Figure 1. Relationships between the three capacities: current and future trajectory.

to industry or end-users as well as develop the commercial nous or academic entrepreneurship to shepherd novel ideas to use. In turn, use – whether commercial or for public good – cannot occur without the necessary networks that can be engaged with. Such *relational capacity* – whether with industries or Māori organisations – requires moving beyond the confines of the laboratory.

SfTI's vision, then, is to develop world-leading science and technology relevant to New Zealand through partnerships between researchers, business, and Māori organisations. Consequently, the focus is not only on technical projects, but also on how researchers extend their leadership and commercialisation skills through participation in workshops and training and on being exposed to relational development experiences with industry and Māori organisations. In other words, SfTI has developed a template of action based, in part, on a redefined concept of absorptive capacity. In turn this has led us to consider the model when viewed from a Māori perspective.

A Māori perspective of absorptive capacity has been outlined generically in previous studies (Ruckstuhl et al. 2019; Ruckstuhl and Martin 2019). Here, we more fully articulate our theory, which we acknowledge is a 'translation' of innovation concepts, and that other approaches start from a Māori or Indigenous worldview (see, for example Walters and Takamura 2015; Kawharu et al. 2017). Notwithstanding this, given our exploratory approach in these novel science areas, translation has been a helpful starting place. Reflecting on the earlier work and our overview of mātauranga in section two, Table 1 is an initial attempt to outline the type of knowledge and understandings scientists need to be able to identify, assimilate and apply to commercial or other use ends, in a manner that resonates with and respects Māori worldviews and values.

First, researchers need to recognise that *mātauranga*, while sharing some similarities with science as a technically complex system of knowledge, is also distinct. As we outlined earlier, mātauranga is based on inter-relationships (whakapapa) and is deeply embedded in the ethics, values and obligations of Māori collectives. Hence, applying mātauranga in the context of science and innovation requires skilled recognition of these patterns of inter-relatedness to draw relevant understandings from traditional knowledge. To assimilate this understanding requires relational capacity and a *tikanga* approach to guide a project upstream at instigation or mid-stream as the technology develops but before the final use is decided. Māori are no longer end-users but rather collaborators or leaders.

Table 1. A Māori perspective of absorptive capacity.

MĀTAURANGA [Technical capacity]	TIKANGA [Relational capacity]	KAUPAPA [Human capacity]
Recognise that	**Assimilate knowledge by**	**Apply knowledge to innovation kaupapa**
• Like science, mātauranga is a technically complex system that generates theories through practices and protocols. • Unlike science, mātauranga intertwines physical & metaphysical knowledge and the animate and inanimate in a system of relationality – **whakapapa** – that reflects and incorporates Māori **values and ethics** • Mātauranga pursues the esoteric (blue-skies) as in science, but its value is in the context of its eventual **collective utility** (within whānau, hapū, iwi).	• Incorporating Māori specialists (science and mātauranga specialists) in the upstream where possible/necessary and mid-stream development of the science • Utilising tikanga/protocols such as wānanga, use of te reo Māori, use of Māori places/spaces to develop/co-construct research and develop understanding of values/ethics • Ensuring that collectively-held knowledge/mātauranga/know-how is acknowledged and protected through formalised means (e.g. intellectual property clauses)	• Which will include Māori-identified commercial objectives alongside consideration of the social, cultural, environmental and spiritual impacts of the innovation • In a way that articulates entrepreneurial opportunities and risks from a Māori viewpoint • Acknowledging mātauranga as an opportunity to expand the set of options for novel science and innovation to benefit Māori

Tikanga can guide both the external and the internal processes of science projects that are of concern to Māori (Hudson et al. 2011; Hudson et al. 2016). This enhanced human capacity will be applied to *kaupapa* that Māori find relevant, such as commercialisation, but that also align to broader social, cultural, environmental or spiritual considerations – in business-speak, the quintuple bottom line. To be entrepreneurial from a kaupapa Māori perspective implies an ability to articulate opportunities – including ability to integrate, where appropriate, mātauranga – and to highlight risks of a particular technology in a way that resonates with Māori values and obligations.

Reframing absorptive capacity in this way, shows that there are points of similarity while also highlighting differences. More importantly it shows that the science and Māori worlds are not necessarily oppositional but have different underlying starting premises (Figure 2). A te ao Māori (Māori worldview) approach starts from the kaupapa position with concerns as to how technical science impacts on the quintuple bottom line. A te ao pūtaiao me hangarau (R&D) approach mostly starts from a technical position and seeks to understand the current state of knowledge in order to expand or stretch into the realms of the scientific frontier to create innovation opportunities. This is unsurprising given that scientists are trained to make technical decisions with little reflection as to the consequences that are derived from such decisions (Harding 2011). Such behaviour is constructed through years of training, reward systems, competition and collaboration between science groups (Geib 2017).

Given these different starting points, a different tikanga or way of relating is needed between research organisations at the science and technology frontier and Māori entities. Upstream engagement requires both parties are able to conceptualise the need for or use of the future applications of the science and technology product or process. Such engagement may involve discussions about how mātauranga will be recognised if it is embodied in a technical use and how benefit will be shared, through intellectual property (IP), patents,

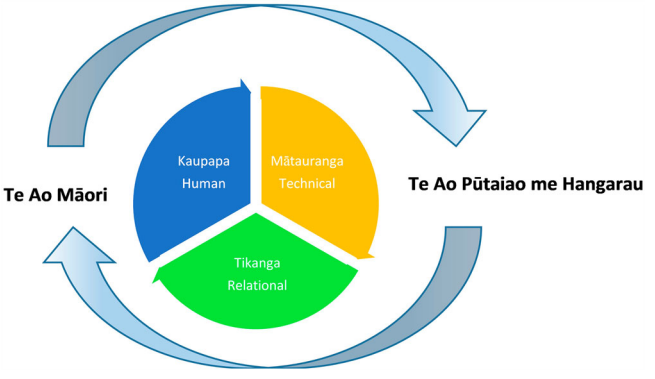

Figure 2. Te Ao Māori vs Te Ao Pūtaiao me Hangarau: differing worldviews.

Note: Figure 2 shows that while a Te Ao Māori worldview starts from a kaupapa position to assess relevance, benefit and impact for Māori of sci-tech innovation, a science worldview (te Ao Putaiao me Hangarau) starts from the technical knowledge frontier space. Relational and human capacity is needed to bridge these worldviews.

licensing and the like. At the meso-level, institutions need to change their operating norms to encourage, demand or model such engagement so that individual researchers and research teams understand what types of behaviours require change. In turn upstream engagement in these spheres requires a degree of technical capacity that for Māori is still developing (Ruckstuhl et al. 2019). How Māori technical capacity is being developed across SfTI and the science sector more generally will be the focus of future studies.

We will outline the impact of this approach in developing a common language and shared sense of purpose with Māori in the following sections, but first we outline our methodology.

Methodology and data collection

As explained earlier, the BNZIC project is a 10-year longitudinal study. A mixed methodology approach was adopted as being able to capture flexibly the range and phases of innovation activities across the breadth and length of the challenge (Denscombe 2014). In the first phase, we used an inductive research design (Braun and Clarke 2006; Eisenhardt et al. 2016) to understand the Māori and scientists' experiences from their perspective. Given that we were working with Māori participants, some of the BNZIC Māori team researchers used a kaupapa Māori research approach, a framework that allows for a suite of methods providing they are consistent with kaupapa Māori principles (Awatere et al. 2017). These principles include forming reciprocal relationships and having a joint approach to research (Brewer et al. 2014). This approach has been important to guiding SfTI organisational processes changes and with developing and maintaining research relationships as we outline later. Ethics approval was received from both a university committee and a separate Māori research consultation committee.

We collected a variety of data, ranging from observations of research team meetings, group and individual interviews along, with examination of primary and secondary material such as reports and case studies. The qualitative data were analysed by individual team members in the initial 1–2 years, followed by team discussions to identify patterns across the various research projects and to understand the organisational processes

being used more broadly. Two quantitative surveys were undertaken in the first three years: a baseline survey of the initial cohort of researchers asking about the extent of prior relationships with research partners, including with Māori organisations, and a business survey that examined, amongst other things, relationships with R&D partners.

These data were then re-analysed to develop focussed research questions, particularly around Vision Mātauranga, Māori world views and the role of intermediaries, from which propositions could be tested with further rounds of interviews and observations. In addition, research observations were shared, both with individual research teams and with the SfTI organisers. From these data, we were able to identify how VM was being implemented at the meso and micro levels. In particular, this has led us at this point of the research to more clearly articulate what is meant by absorptive capacity when viewed from a Māori perspective as we outlined in the previous section.

We now turn to our case study.

Vision Mātauranga and SfTI organisational practice

In light of the previous section's reframing of absorptive capacity, SfTI is shifting its Vision Mātauranga organisational practices to focus on three areas: (1) kaupapa that are Māori identified; (2) tikanga that takes into account Māori-preferred operating principles; and (3) knowledge sharing that focuses on the potential for mātauranga to be incorporated into science for Māori benefit.

As described elsewhere (Ruckstuhl and Martin 2019) the first spearheads were scientist-initiated projects, with few Māori involved in project selection or development. Recognising this as a barrier, SfTI used the 'mission lab' approach to develop large projects by including industry and Māori in the concept phase and then involvement in projects as advisors or participants. The second set of projects have been Māori kaupapa-derived projects in areas such as data, te reo Māori, Māori land shareholding, and water (Ruckstuhl et al. 2019). A more refined approach to project assessment has also been developed. Small seed projects that focus on VM are assessed using a scale that awards points that align to kaupapa, mātauranga and tikanga that is inclusive of Māori participation, in reflection of the reframed view of absorptive capacity outlined in the previous section.

SfTI has also grappled with the notion of intellectual property and the mismatch between science organisations' research contracting practices with Māori partners, and expectations of the Māori community to protect their mātauranga at all phases of the research process. This is particularly pertinent when the type of research that the SfTI challenge might fund is derived from Māori-originated sources, including Indigenous flora and fauna databases and biobanks, as is the case in bio-based additive manufacturing; Māori data collected for administrative purposes; human genome data; and Māori-held data such as whakapapa, land records or Māori language archives. Technology has offered opportunities to researchers and businesses that Māori increasingly wish to understand, make decisions about and benefit from, provided it meets with tikanga, mātauranga and kaupapa expectations. Intellectual property offers one pathway to achieve this. Hence, SfTI has worked with not only Māori data experts through the Māori Data Sovereignty Network (Te Mana Raraunga, n.d.) and the Iwi Chairs' Forum (Iwi Chairs Forum 2018) to hold a series of Māori data workshops in 2018 and 2019, but has also begun a systematic examination of Māori intellectual property practices at a national scale

(Science for Technological Innovation 2018a, 2018b, 2018c; Te Hiku Media 2019). This examination is expected to have wider value beyond SfTI research and aligns with other recent thinking not only in New Zealand (Ngā taonga tuku iho 2018) but also globally (Kukutai and Taylor 2016).

To summarise, reframing the notion of capacity to consider Māori tikanga, mātauranga and kaupapa has aided SfTI to change its organisational practices. However, while as an organisation, SFTI can encourage and even insist that VM considerations are part of any funded project process, this is unlikely to have long-lasting effect on individual scientists and teams. We now turn to the micro-level to examine whether a shared language and sense of purpose is being developed between science teams and Māori groups, and if so, the mechanism that enables this.

Vision Mātauranga at the Micro-level of the science team

As shown in section three, science experts start from the technical perspective. Micro-level studies of academic entrepreneurship have noted that apart from the technical skills of the research scientist, human capacity is strongly influenced by organisational and environmental contexts (Rothaermel et al. 2007; Borges and Filion 2013). There are conflicting institutional norms of university-industry collaboration and divergent attitudes (Mascarenhas et al. 2018) such as the goal of academia being to publish research and to share knowledge openly, compared to the business goal of capturing private economic value from knowledge (Bruneel et al. 2010). Most business entities do not seek out universities as their preferred partners for R&D, given that upstream research is not immediately useful (Lundvall 2016). Therefore, SfTI aims to build the capacity of scientists and teams to engage with industry, and more specifically Māori.

BNZIC researchers surveyed SfTI's first cohort of 63 spearhead researchers which saw 68% (n = 43) respond. Of these, about 40% had prior collaborations with Māori and most agreed that there might be further opportunities to collaborate. However, only one of the initial four science spearheads included a Māori researcher with another two spearhead teams planning engagement such as including a Māori researcher or engaging with Māori at some future point. From a tikanga perspective it was, as one scientist said, 'challenging to see exactly how to engage'. In relation to mātauranga, respondents agreed that science and mātauranga were compatible, that scientists should be familiar with it, and that they were comfortable with incorporating mātauranga into their science, although they did not incorporate mātauranga Māori in actual science projects. There was less certainty as to whether mātauranga would benefit their science. From a kaupapa Māori perspective, scientists saw value in Māori language and customs as part of science engagement and while there was general confidence in speaking to Māori about their technical science, they were less confident in speaking to Māori about Māori things. In sum, while there was an apparent openness to engagement with Māori, there was a lack of knowledge along with what might be described as a broadcaster-receiver approach (Rogers 1983) of science 'push' from the lab to the firm, with uncertainty as to how Māori knowledge might be an inbound innovation capacity (Mascarenhas et al. 2018).

To address such findings, SfTI's human capacity programme incorporates specific activities to induct researchers into the Māori world: Māori economy workshops, attendance at Māori fora, and holding workshops in locations such as marae (Ruckstuhl and

Martin 2019). However, these are only a first step. One of the early findings from BNZIC's research is the key role of Māori intermediaries to help individual researchers and their teams engage with Māori, an insight which we believe will guide future engagement.

An intermediary 'acts as an agent or broker in any aspect of the innovation process between two or more parties' (Howells 2006, p. 720) with roles including: 'match-making' different organisations (Katzy et al. 2013); acting as 'champions' (Martiskainen and Kivimaa 2018, p. 15) articulating innovation needs and visions (Klerkx and Leeuwis 2009); translating ideas and concepts between organisations (Meyer 2010); and acting as architects of new collaboration processes when upstream knowledge practices are still unclear (Agogué et al. 2013). Individual researchers also play intermediary roles in the execution of the technical science with 'gatekeepers' searching for external knowledge then making it understandable for the team, while 'shepherds' take external knowledge and overcome team resistance so knowledge can be used to realise innovation (Ter Wal et al. 2017).

To understand how this works in relation to innovation with Māori, Figure 3 shows how intermediaries played a crucial role in an algorithm collaboration.

This team began with a te Ao Pūtaiao me Hangarau, science-led approach that was investigator-led (1), Māori collaborators 'added-on' (2), and a technical focus (3). An external VM advisor 'matchmakes' (4 and 5) leading to an initial project (6) with the

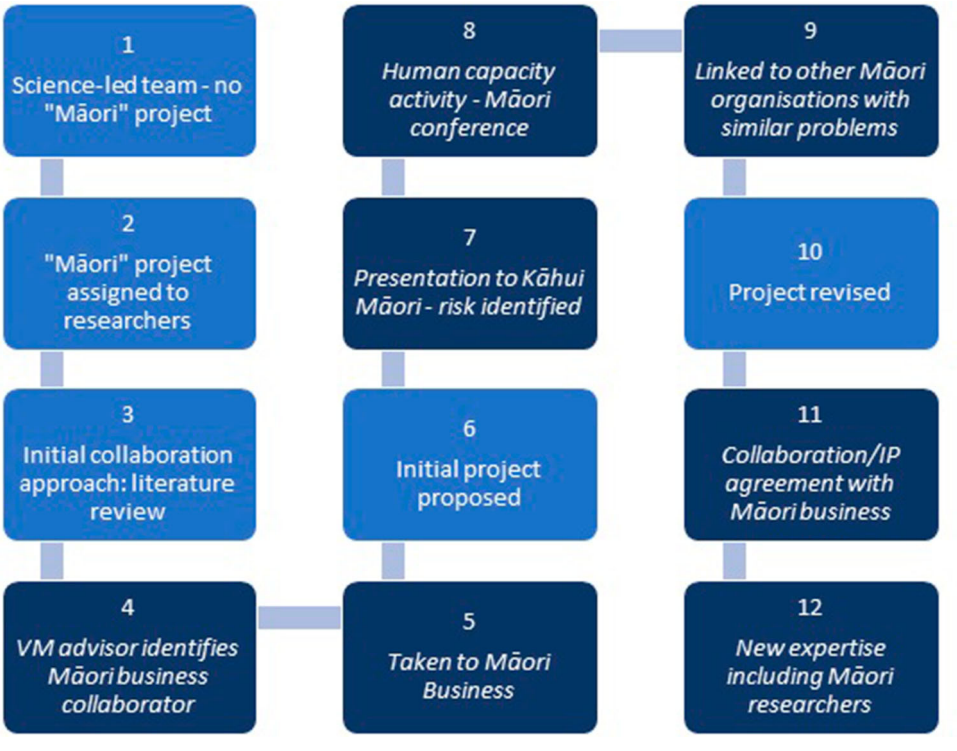

Figure 3. Roles of vision Mātauranga intermediaries.

Note: Figure 3 represents the progress of an algorithm project with a Māori partner and identifies the shift from a te Ao Putaiao me Hangarau (science-led) to a kaupapa led project through the interventions of various types of Māori intermediaries (represented in the dark blue boxes).

Kāhui Māori (Māori advisory group) (7) 'translating' concepts between the science and Māori worlds. A networking event (8) reinforces Māori innovation needs and visions with further matchmaking (9) providing additional knowledge for a larger project (10). However, this required access to new knowledge (mātauranga) with a Māori IP lawyer (11) 'architecting' a new upstream collaboration processes (a contract). The science roles also shifted with the non-Māori PI becoming a 'gatekeeper' championing mātauranga which in turn required involvement of Māori non-science 'shepherds' (12) to help realise science innovation in keeping with Māori expectations.

While the schematic is a simplified representation, some key observations can be made. First, it took over two years to share mātauranga securely to create innovation through the application of a technical process. It is most unlikely that the scientists involved would have anticipated this, thus developing such relationships is time-consuming, at least in the first instance. Second, Māori intermediaries were essential, but such intermediaries are rarely identified, except perhaps at the 'matchmaking' phase. Third, a Māori IP lawyer is rarely recognised as an upstream knowledge architect – more an administrative nuisance – yet here is instigating new relationships not previously in the science system. Finally, the gatekeeper and shepherd are important science roles within teams. With few Māori technical specialists, Māori innovation approaches within science teams are largely absent. Despite this, the example above shows how scientists being open to taking a lead from the Māori intermediaries such as the advisor, the Kāhui and the IP lawyer, coupled with taking up opportunities offered by the human capacity programme, this can overcome such constraints.

This deep dive into the micro-processes of high-tech innovation with Māori reveals the nuanced roles of intermediaries. Beyond the match-making phase, other functions are crucial if mātauranga is to be securely applied to Māori focussed kaupapa. Without appropriate tikanga throughout the whole process, knowledge-exchange, and the innovative power of mātauranga will find a barrier at the science gatekeeper and shepherd roles.

Conclusion

There is a strong macro-level desire to transform New Zealand's socio-technical conditions (Kivimaa 2014) to accelerate R&D transfer to business and Māori for economic benefit. As our study makes clear, this cannot be achieved unless attention is paid to the capacities of the science sector to do so, not just at the macro level of policy, but also at the institutional and individual levels. For Māori to benefit or even to want to participate in this broader national goal requires a conscious and very deliberate set of practices that resonate with and align to Māori innovation aspirations.

From inception, the Science for Technological Innovation challenge consciously focussed not just on technical science but on the way that science is understood and shared with others. The three part framework, originating in the idea of absorptive capacity, has been the attempt to align the heterogeneous assumptions, concepts and norms of science, Māori and business. Our reframing of absorptive capacity has been our attempt to tease out the knowledge and understandings required for scientists to 'get on the same page' as Māori within the innovation sector.

Vision Mātauranga, with all of its contradictory aspects, has been a useful macro-level lever to direct what might happen at the meso or micro levels. But the template

of enactment has been left up to individual organisations and projects. Hence, SfTI has deliberately focussed on how to meaningfully integrate VM into its practices as an organisation, by offering a suite of activities through its capacity development programme and by supporting large and small projects that are Māori-initiated and run from inception.

But this is not enough. Speaking the same language and sharing the same innovation aspirations can only happen at the level of the team and the individual scientist. It is not enough for the 'system' or the 'organisation' to desire this. As we have seen with our deep dive into the algorithm project, potentially transformational innovation is possible but there needs to be awareness of the constituent parts, and in particular the role of the innovation intermediary, both Māori and non-Māori. Moreover, and particularly in the high-tech areas that are the focus of this study, knowledge sharing will not only be time-consuming but will require a quite different way of interacting and delivering science. While this must be factored into any forthcoming projects, and across the high-tech parts of the system more generally, our mātauranga, tikanga, and kaupapa framing begins to lay out upfront what to expect for scientists and Māori alike. This will then allow for the identification of particular roles and capacities, not just the more familiar role of the individual who makes the introductions between Māori and science, but all those intermediaries required as a project moves from inception to completion. We believe that further research at this micro-level is overdue and should be undertaken across the broader science sector to understand not only how these Māori intermediary roles operate but also why, when and where they are necessary.

To conclude, we believe that system-level change is possible, and that Māori innovation insights, knowledge and practice offer exciting possibilities for novel science and meaningful outcomes in the high-tech area. We also believe that these findings are replicable, thus we will be looking to implement and assess these more systematically as the SfTI challenge moves into its second phase.

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