The Potential Role of Artificial Intelligence (AI) in Early Te Reo Māori Language Acquisition

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Abstract

Despite 34% of Māori adults being fluent in te reo Māori, only a small proportion speak the language fluently at home with their tamariki (children). This gap highlights the challenges of language trauma, structural barriers, societal undervaluing of te reo, and broader socio-political factors related to the experience of colonisation. The importance of addressing these barriers is an urgent priority as the survival of the Māori language, central to Māori cultural identity and holistic wellbeing, is dependent on intergenerational transmission.

This thesis examines whether artificial intelligence (AI), integrating Western approaches and mātauranga Māori (Māori knowledge, education, wisdom), can enhance early te reo Māori (the Māori language) acquisition. The thesis aims to address two key questions, 1) How do Western neuroscientific understandings of the role of rhythm in language development and traditional Māori language transmission practices align? And 2) can transdisciplinary AI lend to ethical, safe, socially and culturally aligned AI for use with marginalised Indigenous, tribal, and minority (ITM) communities?

An integrative kaupapa Māori approach guides the research methodology. Through this lens, the historical, cultural, neurobiological and technical aspects of language transmission are looked at to understand how these factors might inform the development of conversational AI to augment te reo Māori uptake in the early years. These tools, when designed with cultural authenticity and in collaboration with ITM communities, offer promising pathways for creating immersive and supportive environments for language learning. However, the risks and ethical concerns surrounding AI development, particularly for Indigenous languages, are scrutinised.

Delving into the neuroscience of infant language development, the thesis seeks to show how early interaction, neural synchrony to rhythm, and traditional cultural practices such as oriori (chant composed and sung to children) and mōteatea (traditional laments or chants) align and contribute to Western understandings of infant language acquisition. These strands of knowledge could be interwoven to create a unique pedagogy for training an AI tool that optimises early uptake of native language. Drawing on research from socio and cultural linguistics, AI science, and infant neuroscience, the final chapter explores a unique Māori cultural framework, Te Wheke (the octopus), to achieve transdisciplinary AI. Transdisciplinary approaches in AI development could hold the key to addressing some of the current social, cultural and ethical concerns that hamper AI use within Indigenous language revitalisation contexts.

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Attestation of authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor used artificial intelligence tools or generative artificial intelligence tools (unless it is clearly stated, and referenced, along with the purpose of use), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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Preface

Orthographic conventions

For ease of reading, English translations directly follow a Māori word the first time it has been used. The reader may refer to the last time the term was used, or alternatively go to the glossary at the end of this thesis for a list of Māori words used.

Following Te Taura Whiri i te Reo Māori (The Māori Language Commission) conventions, macrons have been used to denote the double vowel which creates a lengthened sound.

Outline of chapters

This thesis attempts to provide insight into how traditional Indigeous Māori modes of intergenerational language transmission combined with contemporary neuroscientific Western understandings and AI in culturally appropriate ways, could progress language acqusition in Māori infants in the home.

Chapter 1

Chapter One of this thesis provides an overview, introducing the research topic and key points that lay a foundation, or tūāpapa (foundation), to understand the broad and varied strands, elements and kaupapa that are covered in the seven chapters of this thesis.

Chapter 2

Chapter Two of this thesis examines the methods and methodologies used in this thesis. Building on this is the introduction of Indigenous methodologies. which again. provides a tūāpapa for this research to be understood and interpreted through an Indigenous Māori lens. Several Māori theoretical models will be introduced in this chapter to centralise a te ao Māori world view as critical to guiding the overall methodological approach.

Chapter 3

Chapter Three of this thesis provides an overview of the history of te reo Māori decline through the process of colonisation and the efforts to revive it – beginning with Te Kōhanga Reo (Māori language preschool) and ending with an examination of the latest revivalist efforts that look to harness technology in the quest for language revitalisation.

Chapter 4

Chapter Four of this thesis explores the potential role of AI in the revitalisation of ITM languages, particularly te reo Māori, its limitations and the important ethical and safety considerations associated with this endeavour. This chapter also tackles the subject of risk mitigation in AI design for Indigenous communities, including ensuring data sovereignty and Indigenous rights are addressed along with considering the socio-political implications for Māori and other stakeholders.

Chapter 5

Chapter Five of the thesis examines the fresh neuroscientific understandings around the role of rhythm in early native language development and enculturation. The chapter further explores traditional Māori mnemonic and rhythmic devices used to communicate language within traditional tribal contexts with pēpi and tamariki.

Chapter 6

The sixth chapter is a review of the findings from the material covered across chapters 1-5, with a focus on integrating mātauranga Māori and diverse knowlege streams within a transdisciplinary AI approach. To facilitate the integration of multidisciplinary knowledge, the author will adapt and develop further, a unique Māori conceptual framework, Te Wheke. Previous Māori theoretical frameworks, the Māoritanga Model, Te Tienga and Te Kawau Māro will be used to guide this endeavour.

Chapter 7

In conclusion, chapter seven, provides a summary of key points from the integration, identifying knowledge gaps and opportunities for future research.

Chapter 1: Overview

Introduction

Toku reo, toku ohooho
Toku reo toku māpihi maurea
Toku reo, toku whakakai mārihi,
Kia kore, e ngaro i te pō!

My language, my awakening,
My language, my most precioius possession,
My language, my most spectacular adornment,
You will never be lost, subsumed by the darkness!

If language is the carrier of culture, then it is every child's right to have access to the language of their ancestors. Yet in Aotearoa (New Zealand), it is estimated that on average, between only 1.5 and 15% of parents engage with their tamariki in te reo Māori in the early years at home (Growing up in New Zealand, 2015), despite 34% of the Māori adult population indicating they are able to speak te reo Māori to a high degree of fluency (Statistics New Zealand, 2022). This cultural paradox arises from the tensions and challenges Māori experience in relation to the reclaiming, revitalising and confidence to use their language in the post-colonial context of Aotearoa.

This chapter introduces the research and lays a foundation, a tūāpapa, to understand all the aspects and kaupapa that are covered in the seven chapters of this thesis.

The challenges facing Māori parents

When fluent speaking parents use te reo Māori amongst themselves, and eventually with their tamariki, they progress the goals of language revitalisation, especially through the integenerational transmission of Māori language and culture (Te Huia & Maddever, 2022). However, many things get in the way of this natural transfer. The relationship that adults who are caregivers or parents have with te reo Māori is critical for fostering the use of te reo Māori in the home with their tamariki and wider whānau (family or extended family). A major factor in a parent's decision to learn and use te reo Māori at home is impacted by the valuing of te reo, or lack of valuing, within the socio-political context of post-colonial Aotearoa (Te Huia & Maddever, 2022). Timutimu et al. (2009) suggest, "home, family and the interaction between family members in the home through Māori language are identified as critical pillars of consideration for language survival" (Timutimu et al., 2009, p. 112).

From the Growing Up in New Zealand (2015), study we know that despite the growth of adult speakers in recent years, there are a limited number of parents who actually speak te reo Māori to their tamariki in infancy, regardless of their level of proficiency. This startling contradiction reflects several factors including language trauma and internalised feelings of whakamā (shame or embarrasment), parental understanding of early infant language processes and cognitive capabilities, cost, geographical isolation, access to quality options and language learning resources, a community of practice and support, ongoing colonisation and the undervaluing of the language in current political and social contexts (Ka'ai-Mahuta, 2011; Weisleder & Fernald, 2013). The perception that Māori children and their parents have towards the value of their language is inextricably related to these wider political, economic and social factors. Addressing racism and other social determinants of wellbeing for Māori will have a lasting impact on the acquisition and use of te reo for current and future generations (Growing up in New Zealand, 2015).

The parental, grandparental or adult role is vital within intergenerational language transmission. The home is the primary domain where a child is socialised to their native language - it is where the child acquires the foundations for their first language (Higgins, 2015; Ka'ai et al., 2021). Whānau therefore need increased support to grow their understanding of how to increase te reo proficiency in the home, whilst governments need to invest in effective policy, strategy and resourcing to address the wider political, economic and social barriers to speaking the language (Te Huia & Maddever, 2022). Pohe (2012), maintains that "… the home is where the language revitalisation focus needs to be … when learnt in the home languages are acquired in natural communicative situations." (Pohe, 2012, p.28).

Whilst the recent census shows an overall increase of people speaking Māori in Aotearoa (up 15% from 2018); the number of Māori fluent speakers has remained static over the past 10 years, 18.4 percent in 2013 to 18.6 in 2023, and this of concern (Statistics New Zealand, 2024). Fishman's (1991) Graded Intergenerational Disruption Scale (GIDs) is premised on the notion that if children do not learn a language from their parents, there is little possibility that they will be able to pass the language on in turn to their children. The intergenerational transmission of language was not seen by Fishman (1991) as an onus on parents alone, but contended that structural forces, societal and institutional choices, were critical to influencing parents' decisions around language use (Lewis and Simons, 2010).

Language loss and reclamation

For over 150 years the Māori language has been under serious threat, owing to the imposition of English as part of a forced process of colonisation since 1840. In 1847, the Education Ordinance was introduced by George Grey and the new settler administration to expedite Māori assimilation to the

‘superior’ colonial culture (Walker, 1990). Sir George Grey believed the Education Ordinance would hasten the process by mandating English as the medium of instruction in all native schools (Ka’ai-Mahuta, 2011). The mechanism of the Government’s agenda of assimilation and language domination, from the outset, was to remain the State education system policy towards te reo Māori for decades. This policy was a primary contributor to Māori language loss in Aotearoa. According to McCarthy (1997), the long history of Māori experiences of assimilative policies and practices have been detrimental, not only to language loss, but to overall well-being for Māori communities. Revitalists and activists have fought vehemently against the loss of the language since the introduction of the Ordinance. Those efforts include the establishment of the Te Kōhanga Reo movement in the early 1980s. Fourty years on from the inception of Te Kōhanga Reo and the language is still classed as vulnerable in the United Nations Educational, Scientific and Cultural Organization (UNESCO’s) Atlas of Languages - meaning it requires ongoing and increased efforts to support it to thrive (Ka’ai et al., 2021).

Indigenous language is indivisible from the Indigenous culture and world view from which it emanates. Māori language and culture has evolved through millennia, layering and building ancient and highly complex knowledge systems pertaining to the cosmological, theological, sociological and ecological stratification or order of all things within the known universe. For instance, in the case of Indigenous peoples in Australia, language is connected to land and country because it is there that it originated over 50,000 years ago (Christie, 2007). As Christie (2007) points out, “...neither the shape of the world nor the shape of its languages is ontologically prior. They are co-extensive and co-constitutive ...” (pp. 57–58).

Language, is therefore, not merely a system of communication, but a fundamental part of identity and belonging. Language links an individual to their community and to a particular place (Bow, 2021). The late Whatarangi Winiata's assertion in Luke (2021) regarding the significance of the Māori language for Māori people, should serve as a powerful call to action for all New Zealanders. It emphasises that supporting the future survival of the language is a fundamental aspect of citizenship and therefore a civic duty. As Professor Winiata stated, “reo [Māori] is essential to the long-term survival of Māori as a people. It is not only a means of communication between contemporaries it is the bearer and embodiment of all Māori knowledge across generations” (as cited in Luke, 2021, p.183).

Bright et al.’s (2019) *He Rau Ora – Good practice in Māori language revitalisation* literature review, suggests a multi-faceted approach with a wide range of impactful practices at the micro-level of language revitalisation. These practices are designed to support whānau to use more te reo Māori

language in everyday contexts and situations. "...whānau and community sits at the heart of microlevel language revitalisation" (Bright et al., 2019).

Included in the promotion of these multi-modal approaches is the inclusion of digital resources to aid whānau learning. Chapter Three of this thesis provides an overview of the history of te reo Māori decline and efforts to revive it – beginning with Te Kōhanga Reo and ending with an examination of the latest revivalist efforts that look to harness digital technologies in the quest for language revitalisation.

Technologies and Māori Language Revitalisation

Smart technology is developing exponentially, and revivalists are now taking advantage of these technological aides to halt language decline and accelerate te reo Māori recovery. New and exciting technologies such as Drops, Ka Piki, Tātau, Rongo, Kupu and Kōrerorero, are rapidly changing the language revitalisation landscape in an effort to improve outcomes for te reo Māori. The combining of speech and voice recognition technologies with conversational AI, in particular, holds promise to support novel approaches (Ka'ai et al., 2021). For example, there is evidence that speech and voice recognition capability combined with advanced machine learning (ML) provides for more immersive and realistic environments where language learners can engage in social interactions akin to real-life situations (Nicolaidou et al., 2021). The integration of conversational AI in language education has been gradually evolving, particularly in creating more accurate, natural and engaging models. However, continuous improvement through iterations are essential to support safe, culturally authentic language assistive devices, especially if they are to be used with ITM language communities (Teachflow, 2023). The promise of AI to reverse language shift (RLS)[1] must be balanced with its risk to thwart the goals of revitalisation.

New initiatives leveraging conversational AI to enhance language learning, particularly for ITM languages, employ self-learning predictive models, ML systems, and automated data processing through Natural Language Processing (NLP). These systems and processes create innovative opportunities for ITM language learning (NITI Aayog, 2020). However, equity and authenticity are central considerations within post-colonial contexts where marginalised and low-resource languages are at a major disadvantage. Whilst the potential for AI offers new opportunities for ITM language revitalisation and intergenerational transfer, guaranteeing their survival also necessitates collaboration with ITM communities to ensure control over their intellectual property (IP) and to meet their language revitalisation goals. Smith et al. (2016) describes the challenge of collaboration as a

[1] A term coined by Joshua Fishman (1991) to describe langauge decline

'gnawing sense of mayhem,' where different knowledge systems struggle to coexist within broader inequitable contexts. These power imbalances frequently manifest as insufficient Indigenous language data, a lack of validation or recognition of Indigenous language and knowledge, an absence of, or opposition to, standardisation, ineffective pedagogical tools and incompatibility with existing machine learning 'foundation models.' Additionally, there is often a disconnect between the goals of technological applications and the needs of the ITM community (Mager & Katzenbach, 2021). These issues may also stem from the positionality and worldviews of the designers and developers envisioning these technological futures, especially considering the 'whiteness' prevalent in AI spaces (Cave & Dihal, 2020). Bringing together ITM communities and AI, whilst challenging, is necessary to exact 'Indigenous futurity' where the preservation of te reo Māori and other ITM languages are controlled and led by Indigenous peoples (Tuck & Gaztambide-Fernández, 2013, pp.72-89). Mahelona, (2022), talks to the need for Māori control over AI development, "... if we want to use AI for good, rather than big tech gobbling up our data and selling it back to us, we should empower communities to lead their own platforms and solutions to help move their people forward" (Mahelona, 2022, p.1).

Ethical considerations are a major concern for leaders in AI technology development (Teachflow, 2023). Effective collaboration between AI researchers, cultural experts, linguists, educationalists, neuro and social scientists and other relevant disciplines is crucial for fully leveraging AI assistive capability in the preservation and revival of vulnerable and endangered languages. Chapter Four of this thesis explores the potential role of AI in the revitalisation of ITM languages, particularly te reo Māori, its limitations and the important ethical and safety considerations associated with this endeavour. The chapter also tackles the subject of risk mitigation in AI when working with Indigenous communities, including ensuring data sovereignty, IP and other Indigenous rights are addressed along with considering the socio-political implications for Māori and other stakeholders.

Understanding early learning and the links to early brain and language development

Whilst Māori sovereignty is a critical factor, further ethical consideration is needed when approaching the development of conversational AI for use with tamariki, especially pēpi (babies or infants) in their formative years. Collaboration with experts in early learning, infant linguistics, psychology and neuroscience can shed light on the important bio-linguistic, educational, cultural and psychosocial factors that facilitate healthy language development from infancy. It is only through close cooperation across multiple disciplines that specific linguistic and cultural knowledge can inform successful AI development to aid the early uptake of ITM languages and meet the needs of Indigenous end users.

Stronger links to language, culture and identity are proven to have postive impacts on levels of self-reported wellbeing and increased academic success for rangatahi (young people) (Hunia et al., 2020b; Royal, 2022). These links are formed in utero when brain development is exponential and fresh insights into neural synchronicty to rhythm in language show that rhythm is centrally important to infant language and cognitive development (Lakatos et al., 2019; Markova et al, 2019a). Advances in neural imaging techniques, such as hyperscanning[2], are enabling neurologists to study brain activity between multiple subjects during real-time interactive engagement within natural social contexts. These studies highlight the importance of adult-child interactions in early infant brain and language development, as well as being foundational to social learning (Piazza et al., 2020). Interpersonal neural synchrony (INS), involving neural oscillators[3], supports synchronised brain activity between people (Lakatos et al., 2019; Hoehl et al., 2021). Research by Ruth Feldman (2007) and others (Nguyen et al., 2020; Nguyen et al., 2023; Markova et al., 2019a) show that cooperation and play enhance neural synchrony between infants and their caregivers. Joint attention, affective touch, mutual eye gaze, rhythmic movement, music, singing, and child-directed speech or parentese are also crucial for facilitating this synchrony (Markova et al., 2019b).

Key Māori cultural factors in the transmission of te reo to pēpi

Māori cultural expertise can make a vital contribution to understanding the traditional language and knowledge transmission mechanisms used to transmit language and knowlege to infants, such as mnemonics, semiotics, iconography and the use of highly rhythmic intonations or chants such as oriori, mōteatea and karakia (ritual incantation). The oriori, in particular, was a highly rhythmic mechnism used for transmitting vast amounts of tribal knowledge to pēpi and tamariki throughout their stages of development. Oriori were initially chanted to pēpi in utero and throughout the birthing process - as they made their journey from the kōpū (uterus) through to te ara mōwai (the birth canal), finally arriving in te ao mārama (the world of light).

> …poipoi, is when you are rocking the baby … another name for oriori is pōpō. Pōpō is patting a baby's back, it has a different rhythm. It's a solid, regular beat which sets the beat for the chant of the oriori. Pōpō is also the title of a very famous oriori … it talks about the divine origin of the kumara, when it should be planted, the stars it should be planted under, and when it should be harvested. It transmits an enormous amount of important knowledge [to pēpi] (Gloyne, 2023, p.1)

Recent neuroscientific findings suggest infants begin neural entrainment to rhythm during the third trimester of pregnancy (Nguyen et al., 2023). Combining this knowledge with our cultural understanding of oriori and other traditional rhythmic forms of communiation, can inform approaches

[2] a technique pioneered by Ruth Feldman in 2007.
[3] rhythmic or repetitive electrical activity in the central nervous system, otherwise known as brainwaves.

to designing culturally responsive AI assistive language tools for use with Māori infants. The Fifth Chapter of the thesis will examine the fresh neuroscientific understandings around the role of rhythm in early native language development and enculturation. The chapter further explores traditional mnemonic and rhythmic devices used to communicate language within traditional Māori tribal contexts with pēpi and tamariki.

The sixth chapter is a review of the findings from the material covered across chapters 1-5, with a focus on integrating mātauranga Māori and diverse knowlege streams in AI. The chapter introduces the concept of transdisciplinary AI and explores a unique Māori conceptual framework, Te Wheke, to support the integration of transdisciplinary knowledge, mitigate bias and achieve the development of holistic AI that is best-fit for use within complex linguistic and cultural settings. Adapting the Te Wheke Model for transdisciplinary AI, a model first proposed by Professor Ka'ai in 2022 for the purpose of knowledge integration in Māori AI, necessitates a deep dive into both Western and Indigenous understandings of wheke (octopus), their nature and characteristics. Through this understanding, the wheke as a metaphorical construct can provide a culturally grounded and relevant model for knowledge integration. In conclusion, the seventh and final chapter of the thesis provides a summary of key points from the integration, identifying knowledge gaps and opportunities for future research.

Conclusion

Whilst efforts in language revitalisation have paid off with growth of te reo Māori in recent years, challenges persist for Māori parents, regardless of their level of language fluency, to effectively transfer the language to their tamariki at home. Digital technologies, especially AI, have the potential to accelerate the uptake of Māori language and support natural intergenerational transfer of the language to tamariki and pēpi. Whilst this opportunity is promising, there are however, some critical considerations in relation to developing AI for use with ITM language communities, especially in relation to data sovereignty and IP protection. There is also an increased need for risk mitigation when developing AI for use with pēpi and tamariki. Taking account of the early learning needs of young children and what key factors support healthy brain and language development is a crucial undertaking for AI developers. There are several Māori traditional cultural practices such as the rhythmic chanting of oriori, mōteatea and karakia to pēpi in utero, at birth and throughout their early development that align with recent findings around the important role rhythm plays in early language and brain development. Further exploration of how these ancient techniques could positively impact the transmission of te reo to pēpi in the early years should be considered within the design and development of AI for use with Māori children.

Chapter 2: Research Design, Methods, &Methodology

Introduction

Chapter Two examines the methods and methodologies used in this thesis. The thesis uses secondary sources from which to answer the research question[s]. Building on this is the introduction of Indigenous methodologies which again provides a tūāpapa for this research to be understood and interpreted through an Indigenous Māori lens.

Kaupapa Māori Approach

This thesis takes a kaupapa Māori integrated thematic approach, using a kaupapa Māori decolonising method and methodologies to explore and analyse a wide range of perspectives relating to the key research questions. The corpus under review was located across a myriad of source materials. The central research questions guided the focus of the exploration and thematic analysis.

Methodology

A large proportion of the materials canvassed were located using snowballing techniques from academic publication platforms and sites such as, Google Scholar; JSTOR; MAI; SpringerLink; ArXiv; Semantic Scholar and Wiley Online. The analysis relies heavily on the evaluation of grey materials, journal articles, preprints, policy statements, video, websites and specialist publications from national and international contexts. Criteria for inclusion of artifacts was based on their location within reputable sites and at the author's discretion. Key words and phrases included:

- AI in language acquisition;
- AI and sociolinguistics;
- interpersonal communication and AI;
- language policy and technology;
- Māori language revitalisation;
- ethical concerns in AI for language revitalisation;
- Māori language fluency and technology;
- rhythmic entrainment in language acquisition;
- prenatal language exposure;
- infant brain development and language;
- neural entrainment and interpersonal synchrony in infants;
- prosody in infant language acquisition;

- prenatal auditory experiences;
- infant speech perception;
- early linguistic rhythmicity;
- speech and rhythm development in infancy;
- Māori medium education and pedagogical practice;
- Māori culture, language and identity;
- traditional cultural language transmission;
- oriori and mōteatea;
- Māori oral traditions in intergenerational language transmission.

Scoping these key fields has informed both the methodology and the review of literature.

The method engages a kaupapa Māori and decolonising lens to review the source materials with a deliberate focus on recentring mātauranga or traditional Māori knowledge in the process. To this end, and wherever possible, the voices, views and perspectives of Māori researchers and authors have been privileged. The methodology integrates and blends insights from both Indigenous and Western epistemologies to inform (through its findings) AI technological research, design and development in culturally safe, aligned and appropriate ways for future use with Māori.

Kaupapa Māori Theory and Frameworks

Kaupapa Māori theory is a decolonising praxis that seeks to 're-indigenise' by recentering and legitimising Māoritanga or Māori ways of knowing, thinking and being (Rangihuna et al., 2018). Kaupapa Māori theory can only be exacted by Māori from a te ao Māori position (Smith, 1999; Pihama, 2001; Wehipeihana, 2013). The researcher is of Ngāti Te Ata and Ngāti Kahu descent. Challenging dominant social and theoretical discourse that results in the marginalisation of Indigenous knowledge is an important endeavour for researchers who identify as Māori.

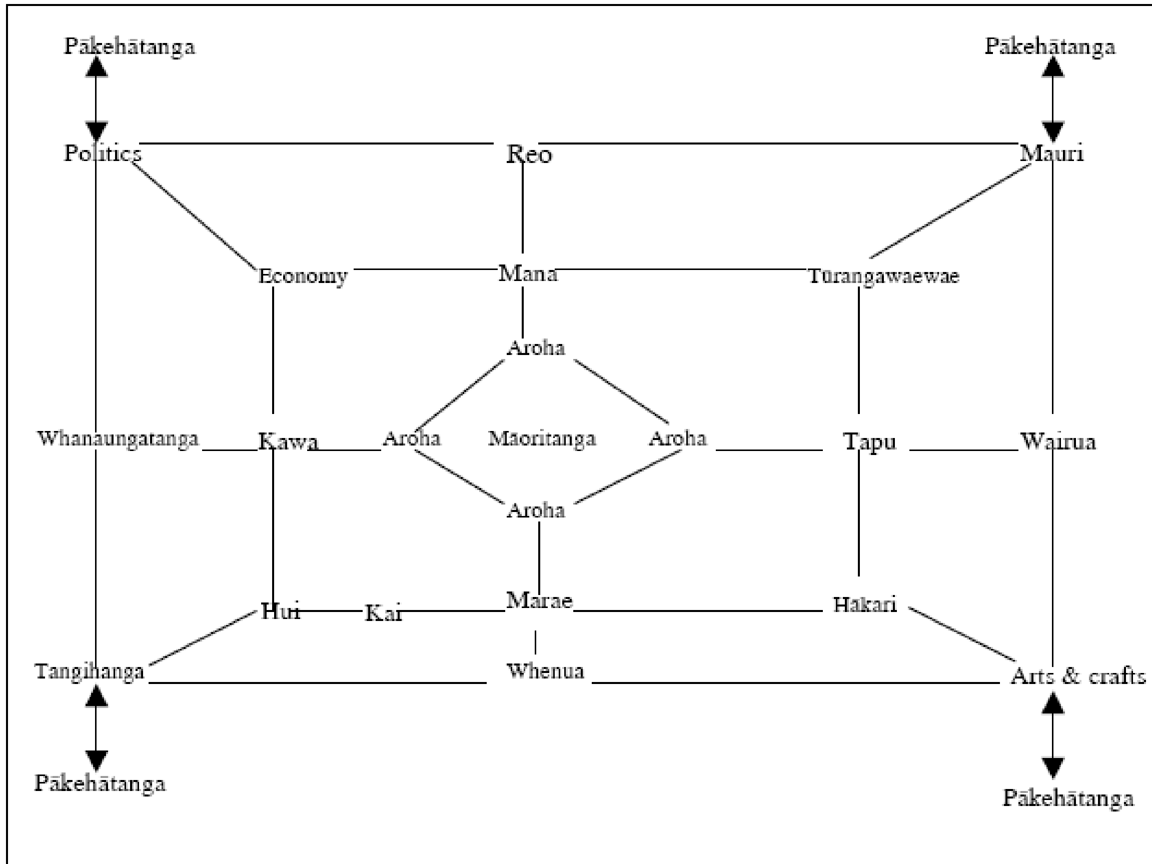
The full expression of kaupapa Māori theory necessitates the development of distinctly Māori frameworks to both locate the researcher and ground the research in Māori Indigenous ontological practices and epistemologies (Smith. L. & Cram, F. 1997).

Māoritanga Model

John Rangihau (1975) espoused the importance of tribalism and locating oneself within the broader homogenised identity of Māoritanga. Kaupapa Māori theory allows for the dynamic and fluid expression of both traditional and contemporary tribal Māori identity. Māori researchers can express

themselves as Māori - moving from peripheral 'other' to central within the research paradigm. Rangihau's ideological model locates Māoritanga or a te ao Māori (the Māori world) view or perspective at the centre.

Figure 1: Rangihau's Māoritanga Model



Note. The Rangihau model was created by John Te Rangianiwaniwa Rangihau. From *Ki te whaiao – An introduction to Māori culture and society (p.16),* by T. Ka'ai et al, 2004, Pearson Education New Zealand. Copyright 2004 by T. Ka'ai et al. Reprinted with permission.

As Ka'ai-Mahuta (2010) states,

> The worldview of the researcher is intrinsic, and therefore, it affects their research in every way. The challenge lies in the search for a model, or method, that accepts the filtering nature of a worldview and therefore accommodates the worldview of the researcher in the research method (p.16)

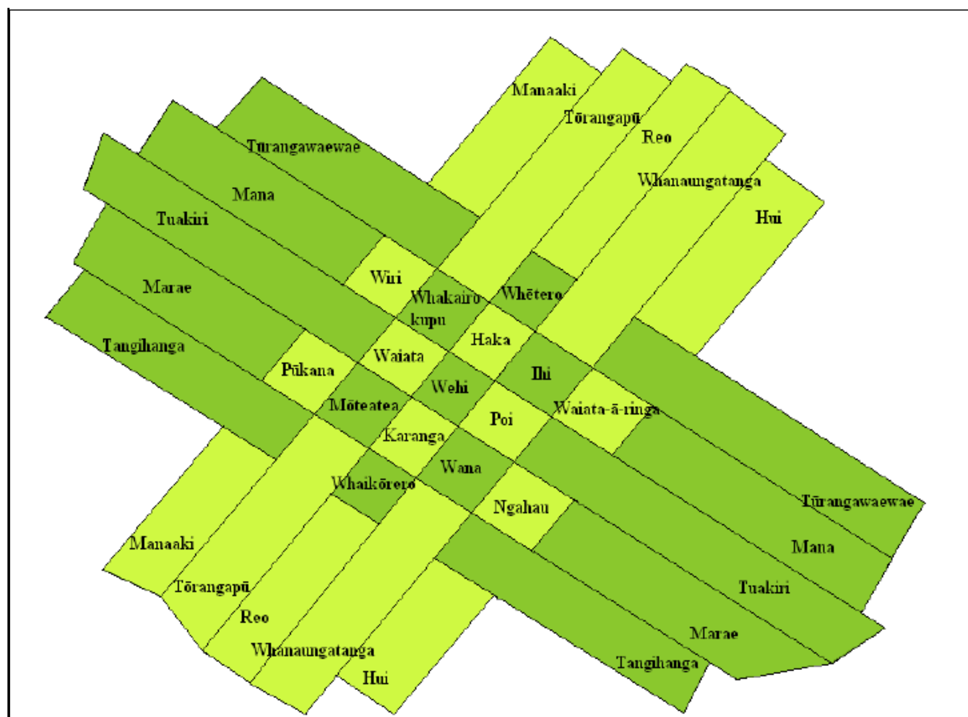
Re-centering Māori knowledge within the academy requires effort on behalf of Māori researchers to engage in the critical mahi (work) of developing Māori-centric theoretical constructs, methodologies, and discourse. Linda Smith (2020) talks about the inherent difficulties in decolonising disciplines to attain intellectual parity (and recognition) within the academy. Smith (2020) asserts decolonising and reconstructing methodologies is often akin to reconstructing a jigsaw puzzle without all the pieces -

recreating through replication as a way of coming to 're' know and rebuild our own discipline that is mātauranga Māori.

Tienga Model

Using the Rangihau Model as a template, Dr Rachael Ka'ai-Mahuta developed the Tienga Model as part of her doctoral studies. The Tienga Model is likened to "an ornately patterned mat ... [that] was only used for ceremonial occasions" (Ka'ai-Mahuta, 2010, p.18).

Figure 2: *The Tienga Model*

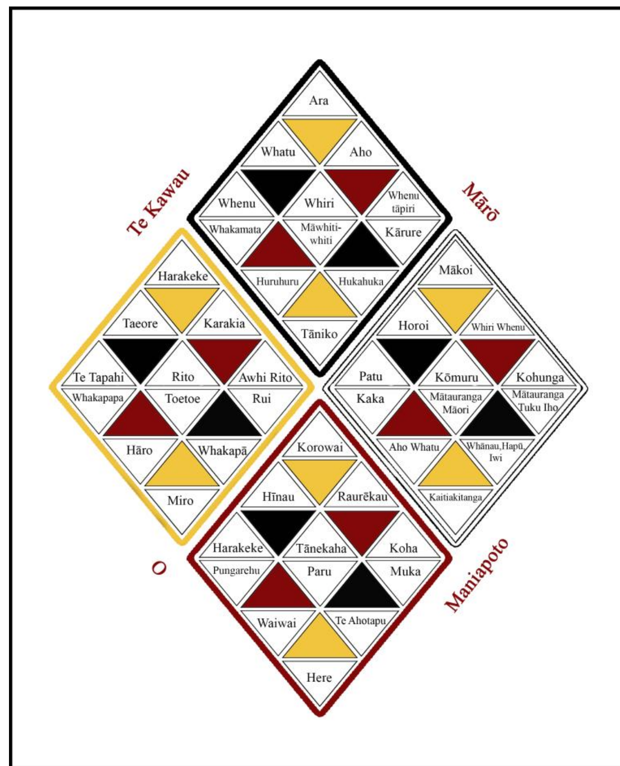


Note. The Tienga Model was adapted from the Rangihau Model by Dr Rachael Ka'ai-Mahuta as part of her doctorate to demonstrate how Māori concepts can be woven together. From *He kupu tuku iho mō tēnei reanga: A critical analysis of waiata (song or chant) and haka (dance) as commentaries and archives of Māori political history* (p.20), by R. Ka'ai-Mahuta, 2010, Auckland University of Technology. Copyright 2010 by Rachael Ka'ai-Mahuta. Reprinted with permission.

From a kaupapa Māori perspective, Ka'ai-Mahuta's model provides significant insight into the holistic nature of a Māori world view through the values and principles that have been illustrated and the concepts that are interconnected using the raranga (weaving) or weaving method (Ka'ai-Mahuta, 2010). Ka'ai-Mahuta uses individual strands to demonstrate the binding of Māori concepts, such as kapa haka (dance group) features of wiri (quivering hands), pūkana (widening eyes) and whētero (protruding tongues) and the disciplines of waiata-ā-ringa (songs with hand actions), poi (swinging ball on string) and haka.

Te Kawau Mārō Model

Figure 3: *Te Kawau Mārō Model*



Note. The Te Kawau Mārō model depicts the strength of weavers and their commitment to the preservation of the raranga art-form as it pertains to the making of korowai. The model is in Gloria Taituha's masters and doctoral thesis. From *Te aho tapu uru tapurua o te muka e tui nei ā muri, ā mua – The sacred strand that joins the past and present muka strands together* (p.36) by Gloria Taituha, 2021, Auckland University of Technology. Copyright 2021 by Gloria Taituha. Reprinted with permission.

Gloria Taituha (2014) developed the Te Kawau Mārō Model as part of her Master of Art thesis. Taituha is a raranga practitioner and created the model to highlight her creative practice and the artefact that she made as part of her thesis. According to Taituha (2014), the Te Kawau Mārō Model,

> consists of four diamonds with 18 triangles in each diamond, a total of 72 inner triangles. Each of the found diamonds [sic] shapes are two triangles joined together, one reflecting the other as a mirror image. The nine inner triangles within each of the eight larger triangles symbolise the battle formation, Te Kawau Mārō (p.19).

According to oral history, Rewi Maniapoto[4] took time to observe the kawau (shag) bird and its flying formations as a flock that assumed triangular shapes. These shapes or formations were then adopted as battle formations.

[4] Paramount chief of Ngāti Maniapoto (Southern Waikato based iwi).

Te Wheke Model for Transdisciplinary AI

This model has been adapted (with permission) from Professor Ka'ai's Te Wheke Model, developed in 2022.

Figure 4: *Te Wheke Model for Transdisciplinary AI*

Note. Te Wheke (the octopus) was originally proposed as a model by Professor Tania Ka'ai in 2022 as a conceptual Māori framework to integrate diverse and multi- disciplinary knowledge streams into a unified whole within AI development. With permission, the writer has expanded on the Te Wheke model (Chapter 6 of this thesis), developing it as a conceptual framework for implementing a transdisciplinary approach to designing a culturally aligned AI for early Māori language acquisition.

Te Wheke provides a culturally relevant and practical theoretical framework for use within transdisciplinary AI development for Māori contexts. It is particularly apt as it holds great cultural significance for Māori. The pūrakāu of Te Wheke o Muturangi, tells the story of a giant octopus that inadvertently became a way-finder for the intrepid ancestor, Kupe, when he journeyed across Te Moana-nui-a-Kiwa (the Pacific Ocean) to discover Aotearoa (Grace, n.d.). Te Wheke is also a natural model to articulate knowledge integration. An octopus has nine brains, one in each of its' eight kawekawe (tentacled arm[s]) and a large central brain located in its ūpoko (head). The ūpoko is the site of knowledge integration, woven from all knowledge streams and transmitted through ngā (plural) kawekawe. The wheke is considered by marine biologists to be one of the most intelligent sea creatures in the ocean. They exhibit problem-solving capabilities, tool adaptation, memorisation of faces and places and are masters of disguise – able to mimic their environment and other sea flora and fauna (Mulroy, 2024). It is therefore not surprising that the octopus is revered, not only by Māori, but by many Indigenous peoples throughout the world - representing intelligence, awareness, agility, altruism and versatility (Furnweger, 2017).

Conclusion

This chapter privileges previous Māori research and lays the foundation for this study by utilising models that exemplify Māori researcher contributions to the development of Māori research frameworks. The models weave together Māori Indigenous methodologies that promote and centralise Māori paradigms and knowledge systems within academic endeavour. In guiding the research methodology and methods for this Master's thesis, Rangihau's ideological Māoritanga Model (Ka'ai, 2004), locates my identity through whakapapa (genealogy) and positions my lens 'as Māori' within the research. Ka'ai-Mahuta's (2010) Tienga Model, expresses the interconnected nature of te ao Māori, where independent Māori constructs are interwoven and indivisible from each other; meaning these concepts are impossible to be understood in isolation. Taituha's (2014) Te Kawau Māro model again, represents the relational synergies within a holistic te ao Māori framing. This framing reminds us that Indigenous concepts are often archetypal, reflecting other scientific, social and cultural constructs and contexts. All three frameworks will be used to guide the adaptation of Ka'ai's (2022) Te Wheke Model for Transdisciplinary AI in Chapter 6.

Chapter 3: Tracing the decline and recovery of the Māori language

Introduction

> Ko te reo, te mauri o te mana Māori. (The language is the core of our Māori culture and mana; the language is the life force of mana Māori). If the language dies, as some predict, what do we have left to us? Tā Hēmi Henare, spoken at the hearing of the Te Reo Māori Claim - Waitangi Tribunal, 1985 (Waitangi Tribunal Report, 1986, p. 34).

Languages are the vehicles for the collective memory of cultures; they are the building blocks of human diversity and essential to maintaining the living heritage and culture of a people. Whilst almost half of the 6,000 known languages of the world are in danger of extinction, the process of ongoing loss toward language death is neither inevitable nor irreversible (UNESCO, 2011).

History of Māori language erosion

An Indigenous language is one that can be described as a naturally occurring system of communication (Timms, 2013). Indigenous is defined as "born of, or… produced naturally in a region, or belonging naturally" and language has been defined as "[a] system of vocal or visible communication using arbitrary symbols in agreed ways" (Turner et al., 1987, pp. 544, 601). The fundamental role of language as a carrier of culture was observed by Pitkin (1972),

> …language is the carrier of the human culture, by which mankind continually produces and contemplates itself … in mastering language, we take on a culture; our native language becomes a part of ourselves, of the very structure of the self. Thus, language has dual aspects: it is our means for self-expression, for articulating our unique individuality; yet at the same time it is what we have in common with other members of our community, what makes us like them and binds us to them (p.3).

Standing as testimony to the centrality of language to Indigenous cultural identity is the assimilationist history of settler societies. In every country where colonisation has prevailed, Indigenous languages have struggled for survival. In Aotearoa New Zealand, the struggle could not be more real. The native or Indigenous language, te reo Māori, was all but eradicated in a little over 100 years of Pākehā (a person of European descent/early colonial settler) influence - from being the first and only language spoken in the mid-19th century, to less than 5% of the population speaking the language fluently by the mid-20th century (Ka'ai-Mahuta, 2011). Rapid decline commenced with the first Pākehā settlers who were Anglican Christian missionaries. Settling in the far North region of Rangihoua in the Bay of Islands in 1814, Reverend Samuel Marsden and Thomas Kendall, with the best of paternalistic intentions, set about establishing the first mission school at Rangihoua in 1816, with the express purpose of converting Māori to the Christian faith.

The language of instruction at the mission school was te reo Māori, with the first written Māori text published in Te Paipera Tapu (the Bible translated into Māori) in 1827 (Te Paipera Tapu 1868, 2024). Translating the Bible into te reo Māori was a pressing task for the early missionaries which commenced with the efforts of Rev Samuel Marsden from 1814 and concluded with the bold expedition in 1821 of chiefs Hongi and Waikato, alongside their guide Thomas Kendall, to Cambridge University to complete the task (Ballara, 1990). Walker (2016) viewed the Anglican missionaries as the advance party in the vanguard of colonisation and cultural dislocation. The mission schools and native schools that followed were both critical and ruthlessly effective in promoting the goals of the colonial settlers and the Crown, hastening Māori assimilation to the dominant English language and culture.

The Education Ordinance

Mission schools were founded by the Church Missionary Society (CMS). These schools taught literacy with a focus on Māori understanding of the scriptures; early instruction was in te reo Māori. By late 1840, nearly every rohe (area) throughout Aotearoa had a mission school. The ratification of this early schooling 'system' took place in 1847 with the introduction of the Education Ordinance (Ka'ai-Mahuta, 2011; Calman, 2012). Governor Grey's first term as governor (1845-1853) was focused on the assimilation of Māori into the practices of the new colony. Assimilation was necessary to grow the colonial economy, and Grey saw an opportunity to use the mission school system to recruit young Māori into manual labour. The Education Ordinance provided economic support for Grey's goals through the establishment of a State- schooling system which was further progressed in 1858 with the introduction of the Native Schools Act. The Native Schools Act introduced secular schooling and a move away from instruction in te reo Māori, promoting a policy of 'English only' instruction (Ka'ai-Mahuta, 2011).

Colonial goals and early conflict

The State education system was a highly successful assimilating mechanism. Tamariki Māori (Māori children) were separated from tribal life and placed into boarding schools, again with a view to hastening the process of 'civilising the natives' and turning them away from barbarism (Binney, 1968). However, Māori opposition to colonial breaches of Te Tiriti saw Māori begin to reject State education, keeping their tamariki away. This shift coincided with mounting opposition from Māori to the blatant disregard by the colonial office of their rangatiratanga (chieftainship or authority), and failure to engage Māori in the development of the colony. Opposition to ongoing breaches spread, ultimately moving the country closer to war (Calman, 2012). The first skirmish between Māori and Pākehā settlers broke out at Wairau in 1843, closely followed by the first engagement with British troops in

the far North between 1845-46, ending at Ruapekapeka pā just south of Whangārei. War spread across the country, in Whanganui in 1847 and Taranaki in the early 1860s. Governor Grey invaded the Waikato in 1863, to stamp out the newly formed Kiingitanga[5] (King movement) (Belich, 1986). The war in the Waikato concluded in 1866 with the withdrawal of British troops and the confiscation of large tracts of Waikato-Tainui lands as punishment for their rebellion. Chiefs, Tītokowaru[6] and Te Kooti[7] led campaigns in the late 1860s, eventually succumbing to colonial forces by 1870 (Belich, 1986). Following the wars, subjugation of Māori through State education recommenced as the colonial machine got back into full swing. By 1871, under the Education Ordinance, Māori were required to part with more land for the building of schools and were also required to pay for the schools' maintenance and upkeep. The first Department of Education was established in 1877, overseeing the management and operation of 57 native schools (Calman, 2012).

Mission schools significantly contributed to the subordination and erosion of Māori language and culture. The Education Ordinance and Native Schools Act were in direct breach of Te Tiriti o Waitangi[8] (Treaty of Waitangi). Monolingual dominance of English was assured through State hegemony and the introduction of education policy that would fail to protect te reo Māori as a taonga (treasure) under Article 2 of Te Tiriti (Ka'ai-Mahuta, 2011).

Corporal punishment enforces assimilation

As aforementioned, the mission, native and State schooling systems became primary mechanisms for cultural eradication and assimilation, shaped by racist legislation (Ministry for Culture and Heritage, 2021). Māori were, however, resistant to these assimilationist policies and te reo Māori continued to be the primary language spoken in the home. In 1880, the Inspector of Native Schools drew up a Native School Code to counter this ongoing resistance. The Māori language was henceforth confined to the junior classes as a means of socialising youngsters to school routines. Thereafter, it was progressively replaced by English medium and instruction in the '3-Rs' reading, writing and arithmetic (Walker, 2016). In 1897, the Inspector of Native Schools attributed poor progress in literacy by Māori to a lack of adherence to the English language. The inspector had the power to direct teachers to encourage children to only speak English in schools, including in the playground. This direction quickly translated to a general prohibition of the Māori language within all school precincts. Subsequent generations of Māori, right up to the mid-20th century, claimed prohibition of te reo was enforced by corporal punishment. A particularly effective implement being the 'cat o' nine

[5] Movement founded in 1858 with the aim of uniting Māori under a single sovereign against colonial rule
[6] South Taranaki prophet and war leader
[7] founder of the Ringatū faith
[8] Founding constitutional agreement between the British Monarchy and Māori chiefs and sub-tribes

tails' a multi-thronged whip used to inflict as much pain as possible - designed to lacerate the skin, whilst requiring minimum exertion on behalf of the enforcer to inflict the blow (Randall, 2006). Corporal punishment, as a deterrent for speaking Māori, was ruthlessly effective, resulting in the swift abandonment of the language by successive generations as parents looked to protect their tamariki from the flail. The impact of this policy had far-reaching consequences for Māori communities. Where tamariki Māori from the same whānau attended the same school, (which was the norm in the late nineteenth and early twentieth century in small rural communities), the notion of guilty by association was rife and wholly damaging to whanaungatanga (relationship/s). Siblings, cousins and extended family members were loath to be seen talking together lest it was assumed they were speaking te reo. This purposeful distancing resulted in isolation and dislocation of whānau and the further fragmentation of collective identity, extended whānau relationships and social cohesion.

Historical trauma

The trauma of settler colonisation has manifested as chronic intergenerational trauma and never-ending for Māori - lasting decades and even centuries following the impact of the initial colonising act/s. That colonisation is an ongoing process means Indigenous peoples are in a constant state of trauma - dealing with historical trauma from past colonial events, whilst new travesties and injustices inflict fresh harm (Reid et al., 2017).

Brave Heart (2000) of the Lakota people, defines historical trauma as "the cumulative emotional and psychological wounding, over the lifespan and across generations emanating from massive group trauma experiences" (p. 245). Events such as the massacres and warfare, enslavement, imprisonment, forced adoptions and removal of children are some of the shared experiences of Indigenous peoples that have been colonised.

Māori continue to experience the trauma associated with land loss and dislocation from whenua, language loss, forced urbanisation, death from war and disease, racist segregation, incarceration, the trauma associated with being beaten for speaking their native language and the impact this had on cultural identity.

Cultural hegemony and the abandonment of language and culture

Cultural hegemony promotes a view that becomes ingrained over time and is soon viewed as the 'natural order of things' (Gramsci, 1971). Within Aotearoa and other settler colonies, the culture and values of the coloniser were perpetuated through all societal structures and institutions, resulting in the systematic devaluing of the language and culture of Indigenous peoples (Ka'ai-Mahuta, 2011).

Ka'ai-Mahuta (2011) asserts that Western ideology and cultural hegemony went hand in hand as part of the settlement strategy, conflating the mana (prestige, authority, or spiritual power) of the dominant language and culture – English. This strategy was further exacted through the self-perpetuating belief that the imposed, ruling-class worldview must be the 'right' one along with its accepted cultural norms. The people of the subordinate culture, in this case Māori, came to believe in their own inferiority and the inferiority of their language and culture. Cultural hegemony as a mechanism of assimilation perhaps had the greatest negative impact on the language, creating rapid language shift. Internalisation of feelings of inferiority eventually took their toll, instilling a readiness in parents to deter their tamariki from speaking their 'inferior' native language in pursuit of mastering the 'superior' language of English.

However, despite all colonial efforts to eradicate the Māori language and culture the goal was not easily accomplished. Throughout the first half of the twentieth century, most Māori remained first-language speakers of te reo Māori. This remained the case until the end of the Second World War (mid to late 1940s) when the picture radically changed (Ministry for Culture and Heritage, 2021).

Competency, proficiency and matriculation

By 1909 most Māori attended boarding school rather than a mission or native school, although many boarding schools were faith-based. The curriculum emphasised tuition in English with a strong emphasis on manual and domestic skills for Māori. The original goal of Governor Grey to build the new colony using Māori as unskilled workers remained firmly entrenched and the State schooling system played its role in producing a Māori underclass to fulfil the demand for manual labour (Walker, 2016). From 1877, academic achievement was assessed by visiting inspectors. Children were passed (matriculated) or failed, and notices of failure or achievement were published in local newspapers. Māori children who were given a light diet of academic tuition failed in the majority and were subjected to a high-level of public shame and humiliation (Walker, 2016).

Yet not all educators agreed with the settler government's racist education policy and treatment of Māori. In 1878, John Thornton, the then principal of Te Aute College, believed Māori could learn the academic curriculum and succeed. Thornton prepared several Māori boys for matriculation – an entry examination to higher-school or University study. The curriculum at Te Aute included English, arithmetic, algebra, Euclid, physiology, Latin, science, chemistry, Greek, French, geography and New Zealand law (Walker, 2016). In the late 1800s several Māori boys from Te Aute matriculated, becoming the first Māori in the country to go on to university study. Tā (Sir) Apirana Ngata was the very first university graduate in 1894, completing a degree in law. Te Rangihīroa (Dr Pita) Buck, Dr Tūtere Wī Repa, Deacon Rēweti Kōhere and Tā Māui Pōmare were shortly to follow him. The early

success of these Māori graduates posed a direct threat to the dominant power structures of the Pākehā settler administration. There was wide-spread fear that Māori who were well versed in the law and public policy could begin to challenge it. George Hogben, the Director of Education from 1899 -1915, refocused the curriculum to strengthen its dual structure, requiring all Māori to engage in hand or manual labour and technical instruction. The new curriculum also delineated and affirmed instruction along gender lines. Boys were instructed mainly in animal husbandry, crop farming and forestry, whilst girls were tutored in sewing and cooking (Walker, 2016). William Bird, Inspector of Native Schools from 1902 -1923, was fully in support of this new policy asserting that the role of the education system was to support Māori to assimilate but not to a point where they would "mingle with Europeans" or compete with Europeans in trade and commerce (Appendix to the House of Representatives, 1906a). Principal Thornton and the Board at Te Aute were something of an anomaly going against the grain and education policy of the day. Te Aute and the Wanganui Schools Trusts resisted the Education Board's curriculum directive which led to a Royal Commission of Enquiry. Thornton, in giving evidence, stated to The Chairman of the Commission,

> What led me to this idea was that I felt the Maoris (sic) should not be shut out from any chance of competing with English boys in the matter of higher education. I saw that the time would come when Maoris (sic) would wish to have their own doctors, their lawyers, and their own clergymen, and I felt it was only just to the race to provide facilities for them to do so, especially in an institution which was a Maori endowment. (Thornton, as cited in Appendix to the House of Representatives, 1906b, p.32)

The outcome of the commission was that Inspector Bird punished Te Aute, suspending all scholarships and meritorious awards for their matriculation programme. From 1907, the two-tier or dual curriculum system was implemented at Te Aute without further opposition. It would be nearly 50 years until the next wave of Māori university graduates. It should be noted here that the first wave of Māori graduates, Ngata, Buck, Pōmare, Kohere and Wī Repa, did not squander the rare opportunities that a formal academic education afforded them. They all became prominent leaders within their hapū (sub-tribe) and iwi (tribe); all had exemplary careers within the church, medicine, academia and politics. The lack of Māori academic role models following the first World War contributed to the ongoing marginalisation of Māori within education and the inability for Māori to have any influence over the socio-economic and political shape of Aotearoa as a growing nation state.

Agricultural and other manual tuition for boys did not serve Māori communities well. Māori were unduly impacted by the great depression of 1939 as enormous tracts of Māori land were confiscated or 'acquired' for settlement. Farming or subsisting off the land became increasingly untenable for Māori who, following World War II, began the great 'urban drift', leaving their homelands in droves to find work in the city centres (Keenan, 2007).

Resistance and turning the tide

The education system maintained and refined its assimilationist policies post-World War II until the release of the Hunn Report in 1960 which recommended greater 'integration' of Māori into mainstream schooling (Ka'ai-Mahuta, 2011). The report sparked outrage and a growing resentment from Māori toward, what they viewed as, an unfettered racist education system with racist assimilationist policies that had not served them well. The State education system had completely failed Māori, resulting in alienation from language and culture whilst delivering poor educational, health and social outcomes. By 1970 and facing total loss of the language, urban Māori activist groups like Ngā Tama Toa sprung up with protestors taking to the streets. On 14 September 1972, Hana Te Hemara, and her fellow activists (including Syd Jackson and Tame Iti) from Ngā Tamatoa, Te Reo Māori Society, and the student group Te Huinga Tauira marched to parliament and presented a petition, 'te Petihana Reo Māori - the Māori Language Petition' with 30,000 signatures (Keenan, 2007). The message within the petition was quite moderate, calling for some inclusion of Māori language and cultural aspects within New Zealand school's curriculum; especially for those schools with large Māori rolls,

> We the undersigned, do humbly pray that courses in Māori language and aspects of Māori culture be offered in all those schools with large Māori rolls and that these same courses be offered as a gift to the Pākehā from the Māori in all other New Zealand schools as a positive effort to promote a more meaningful concept of integration... (New Zealand Parliament, 2022, p.1).

The petition was delivered to Matiu Rata, who was to become the first minister of Māori affairs, helping to set up the Waitangi Tribunal in 1975 (Keenan, 2007). The petition was a significant catalyst in the movement to revitalise the Māori language, culminating in the advent of the Te Kōhanga Reo movement from 1982, the WAI11 te reo Māori claim in 1986, and te reo Māori being made an official language in 1987 (King, 2024).

These early activist groups were supported by moderate and conservative groups like the Māori Women's Welfare League and NZ Māori Council, forcing the government to recognise the need for cultural diversity within education policy and promoting a move away from assimilation. The development of a dual medium schooling system was in part supported with the first Kōhanga Reo operating from the early 1980s. Kōhanga Reo provided for a limited number of tamariki initially to receive instruction completely in the Māori language (King, 2024).

Te Kōhanga Reo and Kura Kaupapa Māori (Māori medium primary and secondary school)

In 1981, the first Kōhanga Reo was opened in Wainuiomata. Kōhanga reo provided early education for tamariki under 5 years old, with the curriculum delivered entirely in te reo Māori. Solely operating

on the efforts of volunteers, the Kōhanga concept proliferated, growing to over 320 Kōhanga Reo operating throughout the country by 1985. The first Kura Kaupapa (Māori medium primary and secondary school) was soon to follow (in 1985), established at Hoani Waititi marae in West Auckland. In 1989, the new Education Act was passed bringing with it radical reform (Keenan, 2007), heralding the first 'taha-Māori' (Māori-centric or Māori side) programmes being introduced into English-medium education settings. Initially these initiatives were funded through the Department of Māori Affairs, however, from 1990, the Ministry of Education took over funding Kōhanga Reo and the establishment of new kura (Calman, 2012). Kōhanga Reo became a flagship movement for the revitalisation of the Māori language and sparked a renaissance in Māori cultural renewal (Morehu, 2009). Māori were now daring to look to the future and an attainable horizon for language and cultural revival. The ebb and flow in the growth and decline of Kōhanga Reo has seen at the height of the movement's success in 1994, over 800 Kōhanga operating around the country. However, a lack of government commitment to actively protecting and growing the language saw a steady decline, with only 460 Kōhanga operating in 2014 (Ministry for Culture and Heritage, 2021). With renewed government efforts by government to promote the language, such as the introduction of Te Maihi Karauna (The Crown Māori Language Strategy) in 2018, there has been improved uptake in enrolments resulting in a small increase in the number of centres, taking the number nationally to 500 in 2020. Despite the recent increase, as of 2020, opportunities for quality, local, early immersion Māori medium placements for tamariki Māori remain scarce with only a relatively low proportion (10.6%) of all tamariki Māori attending Māori-medium early learning (Ministry of Education, 2023).

Fishman (1991) has written extensively about the regenerating of Indigenous and endangered languages through his theory of 'Reversing Language Shift' or RLS. He suggests achieving RLS takes more than a mere desire on behalf of the Indigenous community to revive their language. The systemic barriers and obstacles confronting those whose languages are shifting in the wrong direction are enormous. Levels of legal protection and equitable resourcing are required from government to achieve RLS and reinstate te reo Māori to a language of everyday communication (Hansen, 2012). Two important points that Māori language revitalisation experts agree on is that for te reo Māori to do more than just survive, it must a) be transmitted from one generation to the next and b) be spoken and heard in all domains, especially within the home (Higgins, 2015; Ka'ai et al., 2021).

Achieving RLS through cultural revival

In Aotearoa, Māori revitalisation is embedded within communities of practice that centre around the continuum of Māori-medium education - Kōhanga Reo, Kura Kaupapa and Kura Wānanga (Māori tertiary education institution). At the centre of these Māori-medium education mainstays are Māori whānau, hapū, iwi and hapori (community) who have, from their inception, been the backbone of their

development and survival. Māori leadership in terms of management, operation and the exercising of power in decision making has been key to the ongoing growth and success of Māori-medium education. The whānau management element has been pivotal to transforming the delivery of education services within Aotearoa, moving away from indoctrination to re-vitalisation (Morehu, 2009).

It is therefore unsurprising that the revitalisation of the Māori language has been accompanied by the revival of other integral aspects of Māori culture, especially waiata and kapa haka. In 1972, the inaugural New Zealand Polynesian Cultural Festival was held at Rotowhio, Rotorua (Te Matatini Society Inc, 2023). Initially a small biennial (every two years) affair with 13 groups competing and 5,000 spectators, the festival would be later renamed (in 2004) by Professor Whare Huia Milroy, Te Matatini (the many faces). Milroy coined the term because he said, "Māori Performing Arts brings together people of all ages, all backgrounds, all beliefs, Māori and non-Māori alike, participants and observers. When I look, I see many faces, young and old (Milroy, 2004, as sited by Te Matatini Society Inc. 2023).

Since 2004, the growth of Te Matatini has been rampant and widespread with the hosting of the festival changing event to event, supporting nationwide participation. After a four-year hiatus due to Covid-19, the festival returned in 2023 to the grand stage of Eden Park in Tāmaki Makaurau (Auckland) with 40 groups taking to the stage and an estimated 100,000 spectators attending over the festival's three-day duration. Whilst the main event of Te Matatini is biennial, teams come together for practice and preparation regularly throughout the interim two-year period. Kaiwhiriwhiri Matua (head judge), Paraone Gloyne, (as cited by Doyle, 2023) estimates that the actual festival time constitutes little more than 5% of the actual effort invested by teams. The weeks and months in between each event are critical to supporting language and cultural revival for Māori. Whānau, hapū and iwi come together to speak te reo Māori, sing waiata, engage in kapa haka and reconnect with whakapapa and local histories, both their own and that of the host iwi (Doyle, 2023).

In 2022, Professor Linda Waimarie Nikora and Stacey Ruru, undertook an investigation funded by Ngā Pae o te Māramatanga - New Zealand's Māori Centre of Research Excellence, evidencing the valuable contribution kapa haka makes to the national economy and to Māori health and wellbeing generally. It also contributes to academic achievement of participating young people in Mana Kuratahi and Ngā Kapa Haka Tuarua o Aotearoa competitions and an opportunity for future research into kapa haka as a growing phenomenon within the social, political and cultural landscape of Aotearoa.

Social transformation from urbanisation to a reinstatement of pride in tribal identity are part and parcel of the momentous reversal in language shift that te reo Māori has enjoyed in recent years. Language decline and revitalisation have become 'glocal' issues generally for Indigenous peoples with Indigenous communities making global connections – sharing strategies to achieve RLS in their own territories. Local mita (dialect/s) of Māori are recognisable features of the everyday expression of the language; revitalisation of mita renews a sense of parochial pride amongst Māori communities (Keegan, 2017).

Surviving to thriving

The cumulative negative effects of government policies that dismantled the social fabric of Māori society are being countered by proactive revitalisation policies and actions (Ka'ai-Mahuta, 2011). Positive developments have ensued since the Māori Language Act 1987, including the establishment of:

- Over 400 Kōhanga Reo
- 72 Kura Kaupapa Māori or Wharekura
- Te Taura Whiri i te reo Māori - who's primary aim is to promote te reo as a living language
- Increased funding for Te Matatini
- 29 Māori radio stations
- 2 Māori television channels (one in te reo Māori and one bilingual)
- Te Whare o Te Reo Mauri Ora – Te Reo Māori Revitalisation Framework
- Te Maihi Māori and Te Maihi Karauna - Māori and Government Language Strategies
- Te Mātāwai - an independent entity, working in partnership with the Crown to lead Māori language revitalisation

There are now promising signs that Māori language has turned a corner, away from the threat of extinction with recent statistical evidence of RLS (Statistics New Zealand, 2020). Te Kupenga is Statistics New Zealand's Survey of Māori Wellbeing. Statistics New Zealand reported in 2020 (from the survey undertaken in 2018) that 17.9 % of Māori said they could speak the Māori language fairly well or very well; and 15% claimed te reo Māori as a first language (Statistics New Zealand, 2020). Language revivalists are cautious however to be overly optimistic about the data, stating language revitalisation is a three-generation process (at least) and consistency in implementing long-term strategies is a must (Higgins, 2017, Ka'ai et al., 2021). The reality is that as of July 2023, only 25% of the total New Zealand school population were involved in some form of Māori language learning within a semi or immersive education context within Aotearoa (Ministry of Education, 2020). A culturally responsive system that values te reo and mātauranga Māori is not only possible, but also critical for the future of tamariki Māori (Ka'ai-Mahuta, 2011). Te Maihi Karauna - The Crown Māori Language Strategy 2018, set an audacious goal of one million speakers (of any level of proficiency) by 2040 and actions for the government to prioritise

over the following five years to 2023 to achieve the vision (Te Puni Kōkiri, 2019). The strategy identified three key elements that were critical to RLS,

- WHAKANUI – te reo Māori is valued by Aotearoa Whānui as a central part of national identity
- WHAKAAKO – te reo Māori is learned by Aotearoa Whānui
- WHAKAATU – te reo Māori is used – seen, read, heard and spoken by Aotearoa Whānui (pp.15-16).

The Strategy's efficacy has been evidenced through the General Social Survey (based on self-report data), undertaken in 2018 by Statistics New Zealand. The survey reported that 84% of Māori indicated that they could express their cultural identity either easily or very easily; and 42% were engaged in some form of Māori cultural performing arts, fine arts, crafts and/or sporting activities (Statistics New Zealand, 2020). The number of people able to speak te reo Māori either well or very well increased from 3.7% in 2013 to 6.1% in 2018 and increased again to 7.9% in 2020 (Statistics New Zealand, 2020, Statistics New Zealand, 2022). The latest evidence from the Education Counts Department of the Ministry of Education (2023) on tertiary enrolments in te reo Māori courses, shows enrolment has grown by 93% over the past 10 years. In 2013 enrolments were 19,385 and in 2023 they had risen to 37,415 (Ministry of Education, 2023). However, gaining a clear picture of the trajectory of te reo Māori is difficult without careful monitoring and mapping trends in speaking, understanding and engagement. Recent research has begun to collate, analyse and transform data on te reo Māori usage into an assessment of the current and future trajectory of the language through Te Pūnaha Matatini.[9] The project called, Te Ara o te Reo Māori, analyses data on the health and revitalisation of the Māori language and will in time be invaluable in assessing various strategies and informing where resourcing and efforts should be best spent (Te Pūnaha Matatini, 2024). The evidence from this research is needed to also inform and drive future government policy on te reo Māori. Notably, the number of enrolments in tertiary level te reo Māori courses has increased dramatically over the past 10 years, so investing in servicing this growing demand should provide value for investment in years to come (Te Pūnaha Matatini, 2024).

Whilst ongoing investment and resourcing in current strategies is required to maintain RLS momentum, there is an increasing need to invest in opportunities to promote te reo Māori language use within the home. Ka'ai (2021) asserts, the strongest predictor of language revitalisation and maintenance of a language is the level of language spoken in the home. Ongoing barriers to primary te reo Māori language use in the home domain requires additional investment in flexible te reo Māori resources and learning opportunities. Complementary strategies are necessary to promote collective efforts and diverse approaches to language revitalisation; there is no single *best* method or approach to

[9] Aotearoa New Zealand Centre of Research Excellence for complex system funded by the Tertiary Education Commission and hosted by the University of Auckland.

restoring te reo Māori, advancing one approach over another. Instead, integrated, complimentary "and/and" approaches are required, where all contributions are equally valued (Higgins, 2017; Ka'ai et al., 2020).

Changing political contexts

Ability to speak one's language and connection to culture greatly impacts stable identity development (Timutimu et al., 2009; Wilson & Kamanā, 2011). Since 1982, we have seen two successive generations of Kōhanga Reo graduates grow up to use the language with their own tamariki, resulting in the first wave of new native speakers. The current climate of fluent te reo Māori speakers who are aged 35 and under are beginning to make big bi-lingual waves in what was, until recently, a largely monolingual, monocultural ocean. Youthful leaders, especially young, fluent wāhine Māori (Māori women) such as Te Pāti Māori politician, Hana Rawhiti Maipi-Clarke and the newly named leader of the Kiingitanga movement, Te Arikinui, Ngā Wai Hono i te Pō, are the embodiment and realisation of the vision of those at the forefront of the Kōhanga Reo movement of the 1980s.

The recent announcement in 2023 by the newly elected National-led coalition administration, that te reo Māori should not be the priority language used within government settings, has marked a radical shift in policy direction and a reversal of government commitment to protecting and restoring te reo Māori. Up until recently, anecdotally at least, there were promising signs that the amount of te reo Māori heard within mainstream media channels was increasing and with improved pronunciation. Phrases like 'nau mai, hoki mai' (welcome back) and 'whai muri mai' (coming up afterwards), have been eloquently and effortlessly rolling off the tongues of non-Māori news readers and commentators. Aotearoa had seemingly turned a corner and was on the cusp of unification in the nation's efforts to become bilingual with a perceptible shift in the appetite for te reo Māori. The strong direction from the previous Labour government to normalise the language and support cultural revival had seen increased investment in Kōhanga Reo, increased provision of te reo Māori resources for non-Māori medium schools, the new draft curriculum on Aotearoa New Zealand Histories and Te Takanga o te Wā – Māori History Guidelines introduced (Ministry of Education, 2023). The positive interest in te reo Māori was also evident through the number of people taking up te reo Māori classes with government action on Te Maihi Karauna finally paying off. Whilst the recent gains continue to be positively felt, guarding against a return to language shift is an urgent priority. Utilising all and every means to counter the impact of the deleterious policies of the current administration in Aotearoa will be needed if we are to achieve the goal of one million speakers by 2040. Recent advances in AI present multiple opportunities in the language revitalisation space to stem the tide of Indigenous language loss, particularly when the design and development of these tools are in the hands of Indigenous communities.

Technology and revitalisation – advancing the goals of language restoration

Technology can offer more to Indigenous peoples than just language revitalisation; ultimately supporting communities in the renewal and/or reconstruction of their Indigenous identities and knowledge streams (Huilcán Herrera, 2022). The use of technologies in language revitalisation offers huge potential for ITM language communities to not only preserve their languages but actively reinstate and grow them - intergenerationally transmitting them as living languages. This is made more possible if the technological goals of AI align to and forward the goals of ITM communities. AI is leading a technological revolution of the current age - the Fourth Industrial Revolution (Industry 4.0 or 4IR), with the capability of incorporating increasing levels of human behaviour and intelligence into machines (Maynard, 2015).

AI is a field of computer science focused on creating machines that perform tasks requiring human intelligence. Its goal is to make computers think and learn, enabling them to function like humans (Sarker, 2022). AI-based modelling is key to building automated, intelligent and smart systems to cater to people's everyday needs. AI has been labelled the biggest technological milestone since the advent of the microprocessor, personal computing and the internet. Bill Gates (2023), recently stated, "It will change the way people work, learn, travel, get health care, and communicate with each other ..." (Gates, 2023, p.1).

In the language learning or education space AI technology can give learners personalised feedback, customise or tailor lessons based on their individual learning needs and skill level and to some extent, provide immersive, authentic experiences through conversational practice. Digital technologies are ubiquitous and constantly adapting and changing to meet the needs of communities. The potential of AI technologies to support Indigenous peoples in language and knowledge recovery and revitalisation is a natural progression (Bow, 2021). Whilst Sarker (2022) asserts that AI-based modelling is key to building smart systems for our everyday need, to date AI-based modelling for language learning technologies has largely been limited to adult English-speaking contexts. Indigenous languages have application in everyday life within the culture and an important starting point for language revitalisation is with the youngest generation - pēpi and tamariki. There is a need for AI-based modelling to occur in these contexts, especially to support the next generation of speakers to have access to their language as early as possible (Galla, 2018).

Whilst this is so, the willingness of parents and whānau to utilise technologies with children for language learning may be a barrier given the historical trauma associated with language loss and cultural dislocation. There is an understandable deep distrust amongst Indigenous Peoples toward Western solutions to language recovery and revitalisation (Wilson, 2004). There are also arguments

for and against introducing young children to digital media. Digital technologies, especially multimedia align with the multimodal way that children learn, which is to make meaning through engagement with a wide array of stimuli (text, pictures, words, music, colour, gesture and movement), strengthening and broadening their understanding of constructs of interest (International Literacy Association, 2019). Anti-screen time proponents and those wedded to traditional education curricula are resistant to introduce technologies to children too early. The American Academy of Pediatrics, advocates strictly for parental-mediated exposure to digital technologies for children under 18 months of age and that it should be limited to interactive engagement (i.e., Facetime with other family members) (American Academy of Pediatrics, 2024). Whereas the International Literacy Association (2019) provided cautious endorsement of young children's engagement with digital technologies stating,

> The International Literacy Association maintains that rich, digital resources have a place in early childhood literacy development. Careful, intentional, and developmentally appropriate use of digital texts and tools can build young children's language and literacy skills while providing young children with opportunities to deepen their understanding about the forms and functions of digital text in meaning making (International Literacy Association, 2019, p.1).

Whatever the risks, history has proven that Māori language and cultural revivalists have not shied away from taking advantage of new technologies to support revitalisation goals. In a recent report to gauge the attitudes of Māori parents toward the use of digital technology in te reo Māori language learning contexts, Ka'ai et al. (2022), found that all Māori parents surveyed indicated they would welcome a digital assistive tool to facilitate Māori language learning in the home with their tamariki. This finding aligns to similar findings from studies undertaken in India, China and Brazil, which found parents tended to be less sceptical toward the use of technologies to aid children's learning (Perucica, 2022).

Advocates for increased digital exposure for children view technology as ubiquitous in their lives in an increasingly digitised world and as such digital skill development will be increasingly important for their future wellbeing. Although a different context, it should be noted here that recent research undertaken within the Australian and New Zealand Music and Arts industries has evidenced misgivings and rejection of AI amongst musicians, composers, artists and publishers (Goldhammer et al., 2024). The call for a robust policy and regulatory framework from this sector to protect the rights of creatives and their work has been unequivocally loud,

> Artificial intelligence is just that... artificial. The beauty of human creation is the work of alchemy, not an algorithm. Art is a fundamental form of human expression, unable to be replicated by a machine .... Governments have an ethical and moral obligation to draw a very definitive line in the sand. Enact legislation to protect artists everywhere. Look beyond

> financial frameworks and set ethical boundaries (Tina Arena, as cited in Goldhammer et al., 2024, p.62)

AI in language revitalisation

A pressing issue for Māori and other ITM communities is how to leverage the power of AI whilst protecting the authenticity of the language and culture given its position of vulnerability. Guarding against the exploitation and misuse of Indigenous IP and data is a priority for Māori who have lost so much through the imposition of colonisation. Dr Karaitiana Taiuru (2024a) is an outspoken proponent on Māori and Indigenous data sovereignty. In a recently published article, Taiuru (2024b), provided commentary and key warnings for Māori language revivalists looking to utilise AI in the preservation and revitalisation of te reo Māori. As with other languages, te reo Māori is not readily translated into other languages; it is expected that at least some of the meaning will be lost when te reo is translated and generated by large language models (LLMs) like ChatGPT. This is because much meaning is conveyed not only through text, but via other parts of communication, for example the prosodic aspects - intonation, pitch, meter, and non-verbal body, gestures and facial cues. These elements convey much of the emotion and inflection required to convey true understanding to the listener or receiver (Galla, 2018). This raises concerns about the preservation of the integrity of te reo Māori going forward. Taiuru (2024a), argues that the development of AI interactive language technologies should not occur in isolation of Māori language speaking experts and communities.

> Māori language is perhaps one of the most published and digitised Indigenous languages in the world. We cannot claim ownership of much of what has been digitised. But we can create data that is by Māori for Māori and then ensure some sovereignty and ownership over those data sets. We also need to be careful in what we digitise going forward and ensure there are copyright protections and restrictions from unauthorised usage (Taiuru, 2024a, p.1).

To mitigate the risks, it is important that designers and developers of AI models partner with Indigenous peoples across all related developmental processes such as data collection and storage, pattern mining, machine learning, sentiment detection, reasoning, AI heuristics, training etc. Growing Māori expertise and knowledge in these processes and in related specialist areas such as data sovereignty and copyright law will further guide and support Māori participation in the AI digital sector and build trust for Māori end users.

Conclusion

The history of loss and recovery of Māori language is a story of both historical trauma and Māori resilience. The assimilationist policies of the early settler administration were geared towards total eradication of Māori language and culture. However, efforts by activist groups, whānau and communities to save the language saw the birth of Māori-medium education that would ensure future

generations of pēpi and tamariki would have access to the language. Achieving RLS within three generations has been difficult to achieve with government support for Māori medium education and promotion of the language lacking. Recent investment through committed policy and strategy has lent to large gains in recent years. Support for events that promote the usage of the language such as Te Wiki o Te Reo Māori (Māori language week) and Te Matatini are also adding momentum to language revitalisation. Language revitalisation experts remain cautious, warning against complacency. This is especially so considering the recent coalition government's about turn on encouraging te reo Māori use within government agencies. Innovative approaches and strategies are required to ensure future growth of te reo Māori and digital technologies are presenting promising opportunities for language recovery. Keeping pace with the rapidly moving evolution of AI presents numerous challenges for Māori and other ITM communities, but engagement with these innovations is essential if Indigenous peoples are to leverage the potential benefits of AI. Closer examination of the potential of AI to help or hinder the goals of Indigenous language revitalisation will be explored in the following chapter.

Chapter 4: AI in language revitalisation – balancing the potential with the risk

Introduction

Historically, colonisation, imperialism, capitalism, globalisation, political repression and oppression, disease and the rise of new technologies have contributed to the decline of languages. The English language is fast becoming a global *lingua franca*[10] within the context of linguistic hegemony, especially dominant within the spheres of economics and trade (Zeng & Yang, 2024). As commercial activity becomes increasingly digitised, English is increasingly digitally advantaged and privileged over Indigenous languages. Most of the foundational AI LLMs have been modelled on English for English speaking contexts.

Leveraging digital assistive programmes within language revitalisation will help to improve the digital presence of te reo Māori, a move that is essential to maintaining its relevance and longterm survival in an increasingly digitised world.

The AI Ecosystem and its application in language revitalisation

In 1955, emeritus Stanford Professor John McCarthy, considered by some to be 'the father of AI', defined AI as,

> … the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable (McCarthy, 2007, p.2).

AI systems incorporate both machine learning (ML) and deep learning (DL) which can be considered essential AI technologies, as well as a frontier for AI that can be used to develop intelligent systems and automate processes (Sarker, 2022).

Natural Language Processing (NLP) is a subfield of computer science which enables computers and digital devices to recognise, understand and generate text and speech by combining computational linguistics—the rule-based modelling of human language, together with statistical modelling, ML and DL (Stryker and Holdsworth, 2024).

The integration of conversational AI in language education has been gradually evolving, particularly in creating more accurate, natural and immersive models. However, ongoing innovation is essential to

[10] A common language used for communication between speakers of different languages.

support diffusion and application of authentic language assistive devices for diverse communities. This is especially so if their use is intended with ITM languages (Teachflow, 2023). Again, the promise of AI to achieve RLS must be balanced with its risk to thwart the goals of language recovery. It is clear AI has the power and promise to influence and shape our future more so than any other technological development of the past century (Gates, 2023). Startups and the large commercial 'big-6' tech companies Google, Amazon, Facebook, Microsoft, Apple, and IBM are scrambling to keep pace with one another in the quest to develop increasingly progressive generative models. It is now seemingly an unassailable aspiration to achieve ever-higher levels of machine intelligence and sentience (Ahmad et al., 2023).

The recent release of generative AI models i.e., Chat GPT, Bard Gemini, Claude 3, and others have sparked world-wide excitement, controversy and discourse around both the potential benefits and risks that these LLMs pose for humankind. Since the rapid release of these models there have been endless iterations and improvements in a race by big tech to control the AI space. The very recent announcement by Google of their *Willow* chip is a breakthrough in quantum computing and is set to create another technological revolution with implications for generative AI. The computational power of the chip is enormous and could revolutionise everything from healthcare to finance to scientific research (Williams, 2024). Previously quantum computing was unreliable as the more 'qubits' (quantum bits) of data added the more error-prone and unstable the system became. However, Willow improves on the reliability and stability of the system by adding 'improved' qubits that hold data for longer. The prediction is that Willow is a stepping stone to a powerful quantum computing ecosystem that could eventually tackle some of the world's most complex problems such as climate change, food security and finding a cure for the common cold and cancer (Williams, 2024). With every new revolutionary wave that moves computers closer to being sentient, there is a need to consider the ethical implications. Understanding what constitutes "ethical" development of AI powered technologies, and potentially quantum computing, in the context of at-risk or vulnerable communities is an urgent priority (Ahmad et al., 2023).

The intrepid spirit of tūpuna

Long before departing Taputapuātea[11], tūpuna Māori (Māori ancestors) were designing, innovating, adapting, creating, taking risks and working collaboratively for their very survival. The history of Māori innovation and adaption to new environments and contexts has been largely under-recognised by non-Māori ethnographers and historians (Keegan & Sciascia, 2018). The early migratory journeys and arrival in Aotearoa of our Māori ancestors were proposed by Elsdon Best and S. Percy Smith as

[11] **Taputapuātea** on Ra'iātea Island is at the centre of the 'Polynesian Triangle', a vast portion of the Pacific Ocean, dotted with islands, and the last part of the globe to be settled by humans. The marae sites were built by the *mā'ohi* people from the 14th to the 18th century. Taputapuātea holds outstanding cultural and spiritual significance for people throughout the whole of Polynesia. UNESCO (n.d.).

the "Great Fleet" theory which they claimed was something of an accidental discovery with embellishments of arriving Māori wiping out the country's first inhabitants, the 'Moriori' (tribe native to the Chatham Islands) (Howe, 2005). That version of the arrival of Māori in Aotearoa became entrenched through the history curriculum within the State education system up until the 1960s. Even though it has been repeatedly debunked through carbon-dating techniques and evolutionary theory, many Pākehā still believe the myth of the Great Fleet (Simmons, 1976; Sorrenson, 1979; Howe, 2003; Howe, 2005; Walter et al., 2017).

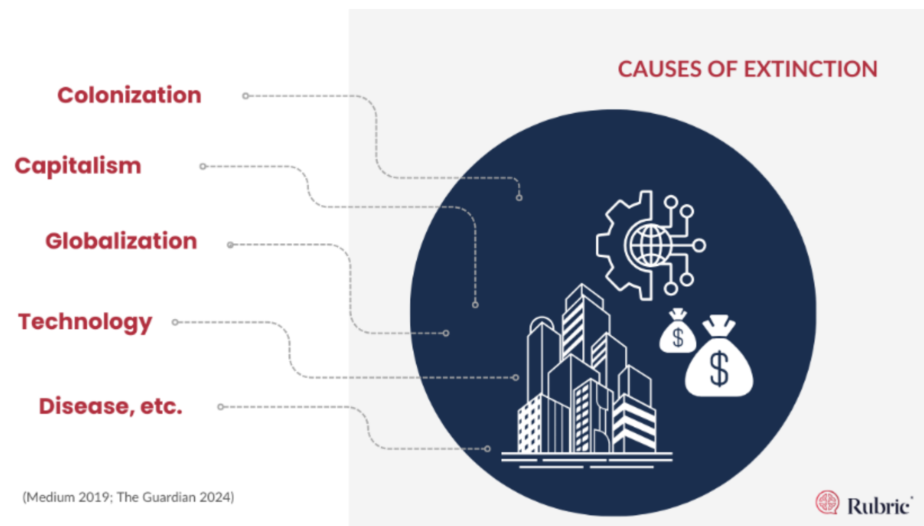
The true story of the migratory journey from Hawaiki (original ancestral homeland) of Kupe and others that followed, has always been known and faithfully retold by Māori (and other Pacific peoples) from generation to generation. The knowledge that our ancestors were ocean wayfaring people and some of the best navigators in the world is now widely accepted (Tuaupiki, 2017). There is mounting evidence that Māori have been traversing Te Moana-nui-a-Kiwa for centuries to trade, gather kai (food) and resources, visit and settle new lands (Tuaupiki, 2017). The large seagoing waka (canoe) built were a feat of engineering brilliance, with 18-meter double hulls and six large cross beams that were lashed together with muka (flax fibre), for durability and flexibility in heavy swells. The sails were also made from muka for durability and were inverted to maximise wind capture. Māori also invented Te Kapehū Whetū (a 300-point Star Compass) that aided in navigation. The renowned master navigator Tā Hekenukumai Busby asserted that, "If it wasn't for the waka we wouldn't be here today and that's the long and short of it" (Tā Hekenukumai Busby, cited by Garcia, 2022).

Māori had an extensive history of creating new technologies based on observation, analysis, evidence, documentation and replication (Keegan and Sciascia, 2018). History has proven Māori to be a highly resilient people, regardless of the significant challenges posed by colonisation, Māori have survived. Foundational to this resilience, has been the ability of Māori to 'cautiously' take advantage of new opportunities - learning from experience when adopting new approaches, tools and technologies. This same cautious but opportunistic approach is likely to be the way Māori generally approach and adopt AI powered technologies. There are some potential ways that AI developers can support diffusion of AI solutions across Māori communities, including verifying that they are safe and secure and that they safeguard Māori data sovereignty.

The potential impact of AI on vulnerable languages

According to UNESCO, (2022), a language dies every 2 weeks,

Figure 5: *Causes of Extinction.*



Note: Figure 5 provides an overview of the contributing causes of language extinction. The systems of colonisation, capitalism, globalisation, introduction of foreign diseases have all contributed to the decline and extinction of Indigenous languages globally. Technology, that is designed to rapidly perpetuate the dominant language and culture of the coloniser is a constant threat to Indigenous languages. However, technologies can also be used to support language recovery and revitalisation. The key causes of extinction were amalgamated into the above figure by Rubric in 2024 for their Blog, *Death of a language: Understanding endangered languages and language extinction*. The figure is reproduced here with permission from Rubric.

Within the current context of technological evolution, AI has the power to either help save ITM languages from digital extinction or accelerate their demise through a lack of inclusion. It is predicted that languages that remain digitally disadvantaged or not represented well within AI development in the future are likely to be at an increased disadvantage and risk of obsolescence. So how do we balance the need for te reo Māori to have a growing digital presence to maintain ongoing relevance, whilst protecting it from exploitation, commodification and homogenisation? Tackling this complex, controversial topic is a task that requires our urgent attention (Taiuru, 2024b).

Cultural safety considerations in AI development

Māori, as with other Indigenous peoples, are wary and alert to the potential risks in treating Māori recorded and published artifacts as 'data ready for mining' or with tokenism through human-centred design that is "for Māori, by others" (Bird, 2020; Skogstad, 2024). In this context, Māori language and culture in digitised forms, could present as 'undiscovered' territories to be appropriated and exploited. This is particularly true where AI development results in the devaluing of Māori language experts and cultural authorities, leading to further disenfranchisement and decentring of Māori language, culture and knowledge systems.

> When one designs with te ao Māori at the heart, and in the foundation and how you work and what you make, the result will be something that feels right for Māori, authentic to us and our way of being (Skogstad, 2024, p.1).

The ultimate risk mitigation strategy would be to have the right Māori expertise guiding the project, or ideally, Māori experts on the project team (Skogstad, 2024). This might not always be achievable within AI projects given the small percentage of Māori involved in digital industries. Approximately 4% of the total IT workforce is Māori and only 14% of Māori take technology as an NCEA subject at secondary school (New Zealand Digital Skills Forum, 2021). Further, a preliminary kaupapa Māori report into the representation of Māori within Aotearoa New Zealand AI commercial, industry and academic landscapes has been unable to identify how many Māori are studying, teaching or working in an AI related field (Taiuru, 2024c). In this climate, other risk mitigation and measures need to be implemented, including diversity planning and co-designing with end-user communities. Oversight and guidance by te reo Māori language authorities and language revitalisation experts is an essential component in ethically developed AI language assistive technologies for use with Māori language communities. Capability building for Māori language experts to gain a fundamental understanding of the basic principles involved in AI development should be considered as a mechanism to supporting their vital inclusion in these projects.

Taiuru (2024b) asserts, there is a pressing need to establish international and local policies and safeguards to protect First Nations communities within AI development globally for language recovery; again, these should be formulated or co-designed "with" Indigenous communities.

International development and protections

The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) is fundamental to upholding the collective rights of indigenous peoples globally. The UNDRIP was ratified in 2007 in front of the General Assembly. Initially opposed, Aotearoa New Zealand eventually reversed our position, assenting to the UNDRIP in 2010. Of interest, 143 countries initially voted in favour of ratification, Aotearoa New Zealand was one of the last four countries (along with Canada, Australia and the United States) to assent. It is by no small coincidence that the last four nation states to recognise the rights of Indigenous Peoples were British settler colonies. Presently, despite providing assurances to the United Nations that a plan for implementing actions to uphold the UNDRIP would be in place by the end of 2023, Aotearoa has no plan. Regardless of the development and implementation of such a plan, any recommendations or resolutions made would be non-binding on the Crown. Articles 3, 4, 5, 15(i), 18, 19, 20(i), 23, 31, 32, 33, 38, and 42 of the UNDRIP protect the rights of Indigenous Peoples to access and control their own data in relation to their peoples, territories, lifestyles and resources. Aside from the UNDRIP, Indigenous Data Sovereignty (ID-Sov)

Rights are underpinned and expanded on through Indigenous Cultural and Intellectual Property Rights under the Mātaatua Declaration and through Indigenous Research Ethics (Hudson et al., 2023). UNESCO's position is that the digitisation of Indigenous data must guarantee Indigenous rights to self-determination and governance over data; to use data in accordance with Indigenous values and common interests, with the free, prior and informed consent [of Indigenous participants] to participate; ensuring privacy and intellectual property rights (UNESCO, 2023).

These statements and declarations whilst important, lack real teeth in terms of enforceability. The lack of enforceable rights is a barrier for Indigenous communities and stronger protection measures are needed. One recent and promising development has been the issuing of Biocultural Labels that recognise Indigenous rights in research data, including digital bio and genetic sequencing information. The biocultural labels were codesigned by Māori and US researchers. The labels contain community information relating to tikanga Māori (correct Māori practice or custom), protocols and permissions for data use. A biocultural label can indicate if consents are required to use the data. This is a promising tool to support IP protection, data security and sovereignty (Anderson and Hudson, 2020; Kukutai, 2024).

Local development and protections

In 2022, Te Tari Taake, Inland Revenue, adopted the Algorithm Charter for Aotearoa New Zealand. The Charter is a commitment to ensuring all people in Aotearoa have confidence in how government departments are using algorithms (The New Zealand Government, 2024). The Charter supports improved transparency and accountability in data use; however, it falls short of addressing issues around Māori Data Sovereignty. It includes a statement on the Treaty Principles, "…embedding a Te Ao Māori perspective in the development and use of algorithms consistent with the principles of the Treaty of Waitangi" (The New Zealand Government, 2024, p1).

This raises serious concerns for Māori, especially given the recent coalition government's commitment to introducing a Treaty Principles Bill[12] that is designed to redefine the principles of the Treaty of Waitangi. Mitigating risks in AI development, requires wider policy and a mix of protections, including Māori data sovereignty audits and tracking of documentation, intellectual property and other legal protections and human rights protections under Te Tiriti and the UNDRIP.

[12] The Treaty Principles Bill was introduced to the House of Representatives on 7 November 2024. On the 19th November 2024, a protest hikoi (walk or march) to Parliament in Wellington, to demonstrate against the introduction of the Bill, took place. The hokoi left from Te Hāpua in the far North – the starting point of the Māori land march, led by Dame Whina Cooper in 1975.

Local protections within AI development are emerging with Te Hiku Media's Kaitiaki (guardian or steward) Licences for its Papa Reo App and the application programming interface (API) that Rongo uses for processing user data that utilises speech detection. The licenses draw on tribal tikanga to specify criteria and conditions for data access, sharing, and use. The Kaitiaki licenses prohibit any use of their API for surveillance, tracking, building Māori corpora, mining Māori data, and anything that is inconsistent with the Principles of Māori Data Sovereignty (Kukutai, 2024). These principles will be discussed more fully later in this chapter.

Ethical concerns

In 2024, Stanford University's Human Centred Artificial Intelligence team released the *Artificial Intelligence Index Report, 2024,* which revealed submissions to FAccT, a leading AI ethics conference, had more than doubled since 2021 (Maslej et al., 2024). The AI Index Report aims to help the AI community, policymakers, business leaders, journalists, and the public navigate the complex AI landscape. Ahmad et al (2023) highlight the importance of addressing ethical concerns from the outset of an AI project, ensuring the centrality of ethics and safeguards throughout design and development - through to implementation and dispersal, so that safeguards are 'baked' into the design. Again, the call for improved policies, standards of transparency and security to guide AI developers and their associates is an unequivocal one (Ahmad et al., 2023).

Hallucinations

The emergence of state-of-the-art AI generative technologies demonstrates the power of LLMs in language revitalisation in that they are impressively fast with multi-modal capability. They can comprehend and translate dozens of languages and produce fluent, coherent text ... yet, despite this progress some significant problems persist (Maslej et al., 2024).

Hallucinations are a type of AI cognitive dissonance or departure from reality. Hallucinations have been defined as LLMs generating content that is nonsensical, erroneous or unfaithful to the provided source content in training processes (Filippova, 2020; Maynez et al., 2020; Ji et al., 2023; Farquhar et al., 2024). LLM systems, such as ChatGPT 4.0, Llama 3.1, Titan or Gemini (formally Bard) have demonstrated impressive capabilities in reasoning and logic, responding with coherent answers to complex questions, yet paradoxically, they also can 'hallucinate' or produce false outputs and completely nonsensical, illogical, unsubstantiated responses (Farquhar et al., 2024).

AI hallucinations are like how humans sometimes see figures in the clouds or faces on the moon. Hallucination accurately describes these outputs, especially in the case of image and pattern

recognition. AI researchers are constantly developing guardrails (measures, tools and ethical frameworks) to prevent misuse and mitigate risks. Techniques like adversarial training—where the model is trained on a mixture of normal and adversarial data are addressing security issues. There are several possible steps that can currently be taken to reduce hallucinations, such as using high-quality training data, clearly defining the purpose of the AI model, using data templates, carefully wording prompts, limiting responses, iterating and fine tuning constantly and ensuring human oversight throughout every process from design to implementation.

As AI moves further into critical areas such as within education and health, detecting and avoiding hallucinations will become increasingly important to maintain trust and confidence in the technology. LLMs are trained to produce plausible sounding text, and this can often lend to arbitrary fabrications and confabulations. Finding new mechanisms for detecting when a prompt is likely to result in a hallucination would help users to construct their questions in ways that reduce their likelihood (Farquhar, 2024). Incorrectly generating Māori words and phrases has large implications for te reo Māori language revitalisation. The potential to alter protocols or tikanga within how the language is understood and spoken threatens to undermine the integrity of the language. In English there can be 20 synonyms for one thing, whereas in Māori there can be one word for twenty things, meaning the language is more nuanced and highly dependent on context (Maxwell, 2023). Variations in mita (dialect/s) and for active and passive tense, change from iwi to iwi, region to region. Currently LLMs, only have text from which to draw an understanding of context, which can be problematic for te reo and may lend to increased risk of hallucinations (Maxwell, 2023). Eliminating hallucinations remains a priority focus for developers of AI in the language revitalisation space.

Mitigating toxicity and bias

One of the persistent issues in AI development is the risk of toxicity and bias. Users have been able to manipulate AI for nefarious intentions including to create hate speech, deep fakes (contrived images that have no basis in reality) or to request the AI provide information that is potentially dangerous such as in the manufacture of explosives. This is partly because these large language models were created by a small number of developers who trained their models on proprietary data and codebases that are owned and controlled by only a small number of companies (namely the big 6, mentioned above) that sponsored them (Box, 2023). This reality raises several ethical questions and concerns such as, what frameworks or regulatory measures hold developers and companies accountable for biased or harmful outcomes? Should developers and companies be required to disclose or open-source their datasets to ensure that biases can be identified and corrected by independent researchers? What mechanisms should be in place to pre-emptively detect and mitigate such risks? And most importantly, who should design these mechanisms?

AI models trained on biased data embed human biases into the codes they generate. In 2015, Amazon undertook a training test to see if an AI trained on previous employment recruitment data could select prospective employees that would be assets to Amazon. To the surprise and somewhat embarrassment of Amazon, they found the system learned an obvious and inherent bias toward employing women by only selecting male candidates (Box, 2023). Experts suggest that to minimise machine learning bias, human expertise remains crucial for reviewing AI-generated code (Roche et al., 2023). A critical question is, which human expertise is indispensable to reviewing data sets, setting parameters and guardrails within AI Māori Indigenous language and cultural projects? Currently only 4% of the digital workforce is Māori, meaning most AI designers/developers in Aotearoa New Zealand are non-Indigenous. Logic would suggest that the margin for bias and error is vastly increased when those interpreting and reviewing Māori specific data and designing, training and developing models for use with Māori, are not Māori. Mitigation strategies to reduce toxicity and bias in AI include diversification of data collection practices, anti-bias training data, and standardised bias detection methods (Roche et al., 2023).

In weighing the risks of ML bias within Māori contexts against the need to exploit the power of AI for Māori language revitalisation we need to find ways to continue to explore the opportunities whilst minimising bias, toxicity and other risks. Developing a clear set of ethical guidelines to address the issues of data sovereignty, privacy, bias mitigation, and code ownership will go a long way to preventing potential risks AI poses to Indigenous communities (Roche et al., 2023). The existing international and local policies, techniques, approaches and resources (outlined above) should be central within AI design for ITM language communities; ongoing exploration of additional protections should be undertaken to increasingly make AI safe for use in these contexts.

Finally, co-designing AI with Indigenous communities should be a not-negotiable given the potential flow-on benefits such as improved accuracy within data sets, improved protection, including to the mana (prestige, authority, or spiritual power) of language experts and cultural authorities and the building of intergenerational community capability in AI (Skogstad, 2024). Building transdisciplinary teams around AI development projects promotes multiple and diverse perspectives to reduce bias. The potential to facilitate transdisciplinary AI through integrating multiple disciplines will be explored in chapter 6.

Ethical engagement with Māori communities

Koha (gift/gifting) is an act of reciprocity and is a central tenet or tikanga within Māori society. Exchanges of koha ‘in-kind’ can be expressed through whanaungatanga or relationships and connections (Mead, 2003). Whakapapa and whanaungatanga and the relational ties that bind, come

with inherent obligations to be caring and 'in return' to be cared for. In working with Māori communities, developers of technologies need to ensure that they are reciprocating and demonstrating care for the communities they are working with. Researchers, designers and developers of AI, especially non-Māori, are enormously privileged to have access to the tools and skills of the language experts and knowledge holders within the community. Giving back via koha can take numerous forms including, ensuring the community have the ongoing support and capacity to maintain, adapt and develop their own tools in the quest for language revitalisation and continuing to grow community capacity and capability in AI development. These endeavours should also be part and parcel of the exchange that requires researchers and developers to invest in building whanaungatanga over time. This necessitates sustained engagement rather than a 'drag and drop' approach to co-designing new technologies with hapū and iwi. Offering opportunities to emerging local AI researchers and developers to grow their skill, providing ongoing training and support, and continuing to grow the wider community's digital literacy, knowledge and capacity supports Māori to be self-determining in their own technological futures (Huilcán Herrera, 2022).

Ensuring Māori Data Sovereignty

Moe Milne talks to the inherent nature of data as a taonga to be protected, "he taonga te data i tangohia mai i te tangata, i te mea ora" (Milne as cited by, Te Mana Raraunga - Māori Data Sovereignty Network, n.d).

Te Mana Raraunga (TMR) is the national Māori Data Sovereignty Network. Established in 2015, the network was initially developed from a workshop on the implications of the UNDRIP for the collection, ownership and application of data pertaining to Indigenous peoples (Te Mana Raraunga – Māori Data Sovereignty Network, 2018). In 2018, TMR developed six key Māori Data Sovereignty principles. TMR advocated for the recognition and protection of Māori rights and interests in data as derived from inherent rights as Indigenous peoples. These rights are conferred through whakapapa, connections to land and taiao (natural environment) in Te Tiriti o Waitangi and in the UNDRIP. These principles guide the ethical use of data to enhance the wellbeing of Māori people, language and culture (Te Mana Raraunga – Māori Data Sovereignty Network, 2018). The Principles of Māori Data Sovereignty identified by TMR are outlined in Table 3, are based on six key tikanga Māori (correct Māori practice or custom) values or principles – rangatiratanga, whakapapa (genealogy), whanaungatanga, kotahitanga (unity), manaakitanga (care for others) and kaitiakitanga (guardianship or stewardship).

Table 1: **Principles of Māori Data Sovereignty**

Principle	Sub-principle	Description
01 Rangatiratanga	**Authority**	
	1.1 Control	Māori have an inherent right to exercise control over Māori data and Māori data ecosystems, including creation, collection, access, analysis, interpretation, management, security, dissemination, use, and reuse of Māori data.
	1.2 Jurisdiction	Decisions about Māori data storage (physical and virtual) should enhance control for current and future generations, prioritising storage in Aotearoa New Zealand.
	1.3 Self-determination	Māori have the right to data that supports sustainable self-determination and effective self-governance.
02 Whakapapa	**Relationships**	
	2.1 Context	All data has whakapapa (genealogy). Metadata should include information on the data's provenance, purpose, context, and the parties involved.
	2.2 Data disaggregation	The ability to disaggregate Māori data increases its relevance for Māori communities and iwi. Māori data collection should prioritize Māori needs and aspirations.
	2.3 Future use	Decisions made about data today can affect future generations. Māori data governance should aim to prevent future harm.
03 Whanaungatanga	**Obligations**	
	3.1 Balancing rights	Balancing individual rights (including privacy) with collective Māori rights, where collective rights may prevail in some contexts.
	3.2 Accountabilities	Individuals and organizations handling Māori data are accountable to the communities, groups, and individuals from whom the data originates.
04 Kotahitanga	**Collective benefit**	
	4.1 Benefit	Data ecosystems should be designed to enable both individual and collective benefits for Māori.
	4.2 Build capacity	Developing a Māori workforce to handle data governance, including creation, collection, management, security, and application.
	4.3 Connect	Supporting connections between Māori and other Indigenous peoples to share strategies, resources, and ideas for achieving common goals.
05 Manaakitanga	**Reciprocity**	
	5.1 Respect	Data collection, use, and interpretation should uphold Māori dignity, avoiding analyses that stigmatize or blame Māori, which could cause harm.
	5.2 Consent	Collection and use of Māori data should be based on Free, Prior, and Informed Consent (FPIC), with stronger governance in cases of less-defined consent.
06 Kaitiakitanga	**Guardianship**	
	6.1 Guardianship	Māori data should be stored and transferred to enable Māori capacity to exercise kaitiakitanga (guardianship) over their data.
	6.2 Ethics	Māori data protection, access, and use should be based on tikanga, kawa (protocols), and mātauranga (knowledge).
	6.3 Restrictions	Māori have the authority to determine which data is controlled (tapu) or accessible (noa).

Note: Te Mana Raraunga produced the six principles of Māori data sovereignty in Table 1 to ensure Māori rights and interests in data derive from the inherent rights Māori have as Indigenous peoples, and their unique relationships with land, water and the natural world as recognised both in Te Tiriti o Waitangi and the UNDRIP.

The work of TMR, to define key principles that protect Māori data sovereignty is exceptionally important to providing a strong platform for guiding government and social policy on how best to protect and uphold Māori rights and interests in data management. These rights are inherent to Indigenous peoples and derive from their inextricable connection to whakapapa, whenua, taiao, te reo

me ngā tikanga Māori and everything that relates to te ao Māori. The Principles of Māori Data Sovereignty should be regularly reviewed and revised in step with current and future AI and technological developments to ensure they continue to be best-fit for Māori communities.

Federated Learning (FL) and Hybrid FL, and sandboxing

Storing large amounts of sensitive data in the Cloud poses significant security risks to privacy, security, data sovereignty, control and access to Indigenous cultural heritage and knowledge (Adams & Thom, 2016; Sharma et al, 2023). Federated learning (FL) can facilitate the ability to share raw learning data and train ML models. Unlike centralised models, FL does not require the sharing of user data using Cloud processing, making it infinitely more secure (Sharma et al., 2023). In FL the data remains on a local device or server with all model updates exchanged between users before being uploaded to a central server, thus preserving people's privacy and security and limiting cyber-attacks and data breaches (Sharma et al., 2023). Google's keyboard app, Gboard, for example, uses FL to improve text predictions without collecting user typing data (keystrokes) centrally. More recently, Hybrid Federated Dual Coordinate Ascent (HyFDCA) has emerged as a novel algorithm that is an improvement on existing FL models. The technique improves on privacy steps to ensure privacy of client data in the primal-dual setting (Overman et al., 2024). FL and HyFDCA should be explored further for its potential to protect the privacy and data of Māori and other ITM language communities. An active direction of research is to develop FL and HyFDCA for training heterogeneous local models[13] with varying computation complexities, producing a single powerful global inference model. A large challenge for AI developers is that FL and HyFDCA models require good connections between local servers and minimum computational power ((Liberti et al., 2024). Open data sharing can undermine the rights of Indigenous communities by 'democratising' data, limiting Indigenous people's sovereignty and decision making. FL and associated models maybe the answer for improved secure, community-consented data ownership and sharing (Boscarino et al., 2022). Revolutions in *Willow* and future quantum computing chips may minimise or eliminate the current challenges and limitations associated with Federated models.

Māori traditional cultural knowledge and data is a taonga and considered tapu or sacred, the protection of which is of critical importance to Māori people. Previous experiences of colonialism and working with researchers from predominantly white Western institutions has led to the historical misrepresentation of Māori data (Savage et al., 2021). This misuse, especially in the application of erroneous findings, has resulted in a deep distrust and scepticism amongst Māori and other Indigenous peoples toward non-Indigenous researchers and their research aims (Boscarino et al., 2022). Given the history and scepticism, open-access data policies are not appropriate for use with ITM language

[13] Heterogeneous local models enable each device to train a model that suits its data and constraints.

communities and may act as “just another form of colonial dispossession” (Tsosie et al., 2021, pp.183-186).

Within AI development creating a secure, isolated environment through techniques such as *sandboxing* may help to alleviate some of this distrust. Sandboxing is a cybersecurity practice that runs sensitive or potentially dangerous code in a safe, isolated environment - allowing it to be tested and evaluated locally without affecting other parts of the system or providing unauthorised access (Fortinet, 2023).

Reducing variance and/or balancing variance and bias

Variance in machine-learning (ML) occurs when machine learning algorithms create vastly different results than expected (Belcic & Stryker, 2024). Balancing variance and bias in parameter setting can reduce variance and improve accuracy. Hyperparameters and setting the right level of complexity can counter variance. Hyperparameters are configuration choices that determine how ML algorithms learn from the data, and they are essential for fine-tuning models to achieve optimum performance (Belcic & Stryker, 2024). Hyperparameters are set by the developers before the training of a model begins and it is important that developers ensure there is the right mix of hyperparameters embedded in their models. Other techniques such as cross-validation, regularisation, and ensemble learning, underfitting and overfitting (balancing variance and bias) have been proposed as effective in reducing variance in oversimplified AI models (The Pecan Team, 2024).

Transparency and Human Oversight

Transparency is all about making AI trustworthy through increasing understanding of AI systems and how they work, including how their logic functions and how they make decisions. Understanding the ‘why’ and ‘how’ an AI has shaped a particular narrative or arrived at a particular solution, helps to build human trust in their processes (Jonker et al., 2024). Transparency also relates to knowing what safety mechanisms have been employed, including what ethical steps have been taken to ensure the technology is safe for use before deployment.

Transparency can be achieved at a high level, through having a set of clearly defined principles such as those produced by TMR and evidencing where those principles are being applied and embedded throughout the AI lifecycle by using disclosures and sharing information about the AI design and development process. Disclosures could include describing the purpose of the AI, providing information on how the model was generated, by who, the training data source, training and testing processes, mitigations for bias and hallucinations, fairness and adversarial metrics and contact details

so that people can ask questions. Whilst this sounds like a daunting task, there are now templates and tools available to gather and publish this information (Jonker et al., 2024). Depending on use case, format should be considered, i.e., print or digital media, video, blog post, website, etc. Audience should also be considered, i.e., is the information intended for data scientists or end users?

In June 2024, the European Union (EU) introduced new legislation, The EU AI Act that lists general provisions, prohibited practices, high-risk AI systems and activities, and (Article 50) transparency obligations. Under article 50, producers of AI must make end users aware they are interacting with an AI system and not a human person. All generated content including audio, text, video, images, must be clearly labelled or marked as being generated by AI. Generator and deployers of AI systems must ensure human review and human editorial control throughout the lifecycle of the AI.

Collaborating with end user communities to reduce inequities in AI development

In a recent study, Soylu and Sahin (2024), found AI significantly supported language learning tools, community engagement, accessibility, and content creation. However, they also found that AI presents a risk to potentially increased barriers and equity gaps for Indigenous peoples. This is especially so, if the development of AI does not address technical, cultural and social barriers, along with financial and resource constraints.

One way to ensure equity is to adhere to the principle of ‘nothing about us, without us’ as a strong ethic within AI development that requires working ‘with’ Indigenous communities as a non-negotiable. AI development companies and actors must be educated in the TMR principle of Kotahitanga - working collaboratively and in cooperation with Māori and other ITM language communities. This is a critical consideration for all people working within the AI industry (Bird, 2020).

Conflicts relating to authenticity have arisen in relation to notions of standardisation or unification of language dialects within digital contexts into a single uniformed language (Benedicto et al., 2002). These homogenising and assimilationist practices have the potential to hamper language-revitalisation and the self-determination of Indigenous peoples. To date efforts to standardise te reo have largely focused on the lexical and technical elements of the language and promoting orthographic consistencies in written Māori (Keegan, 2017). Increasingly, the reclaiming of te reo Māori is more nuanced, focusing on the reclaiming of linguistic differences, such as local dialects, idioms, etc. Keegan (2017) suggests this relates more to ideological factors and changes toward language revitalisation and identity reclamation. Whilst the destination maybe the same, many whānau, hapū

and iwi are at different points on their language revitalisation journeys. It is therefore critical to involve local communities in the design and development of AI digital language tools to ensure the unique goals of each language community are at the forefront.

Building diversity across AI teams

Structuring teams so that a range of perspectives are included in the design has far-reaching benefits that go beyond the development process, extending to increased understanding of potential and specific use cases, contexts, and firsthand experiences (Boch & Kriebitz, 2023). The AI industry is highly under-represented in diversity, with black and Indigenous peoples making up 2.5% of Google employees, 4% of Facebook and Microsoft employees and only 22% of women globally are AI professionals (Howard & Isbell, 2021). This lack of diversity hinders the development of AI tools, reducing their diffusion and application. Diverse teams bring varied backgrounds and experiences, making them sensitive to different issues and potential use cases - designing AI tools that better reflect the richness of human societies. AI technical expertise is essential, but diverse perspectives from non-AI professionals provide unique viewpoints on data collection, use, sovereignty, protection and privacy. Involving humanities and social scientists, artists and creatives, as well as individuals from diverse ethnicities, training backgrounds and life experience throughout the AI lifecycle promotes inclusivity, ethical approaches, and targeted development for diverse populations (Boch & Kriebitz, 2023).

Building diversity within teams can be easily achieved through scholarships, cadetships or mentoring programs and actively seeking representation from diverse contributors and end users or stakeholders. Overall, diversity helps to mitigate bias and improve implementation throughout AI development and deployment (Boch & Kriebitz, 2023).

Strengthening Identity through digital language profiling and positioning

AI technologies also support language revitalisation efforts of Indigenous communities through their very existence. Simply seeing te reo Māori language digital content in AI applications can have a positive impact on identity development, especially for rangatahi Māori - validating and affirming the importance of their native language (Galla, 2018).

> If [te reo Māori] doesn't have a digital future, it's going to be very difficult for us to ensure that it is an option for communication in the world that our mokopuna will live in. (Lucas-Jones, as cited in Natanahira, 2024, para. 19).

Validating languages digitally has much greater impact when communities are active agents in the process, including having ownership and governance over the design and production of revitalisation materials and tools (Galla, 2018).

> In a digital world, it means Internet chats in Indigenous languages, Indigenous web pages, multimedia CD-ROMs for learning Indigenous languages, and cultural information published by Indigenous groups for a global audience. These are proven examples of how traditional knowledge and modern technology can be blended. Without a doubt, Indigenous people are aware of the importance of media and technology to revitalize their languages in contemporary times. (Lieberman as cited in Coronel-Molina, 2019, p. 93)

Eisenlohr (2004) argues that revitalisation efforts involving the use of technologies can support the recognition and promotion of identity as a political marker. Within Aotearoa, this marker of identity locates Māori within the context of post-colonial revitalisation. AI then becomes a tool for emancipation in the fight for the restoration of Indigenous rights. The discourse of cultural revival within AI underscores the notion of identity as non-static and evolving (Huilcán Herrera, 2022). This is in contrast of the views of language revitalisation purists who often treat Indigenous language as a static found object.

> Already we have seen several international companies using digitised Indigenous language resources to train their own AI for commercial purposes, then promote those systems back to their communities as an AI translation solution for profit (Lucas-Jones, as cited in Natanahira, 2024, p.1).

Nina Sangma (2024) talks about the protection of Indigenous rights being, ‘counterintuitive’ to the values of big tech for whom AI development is ‘business as usual’ (Sangma, 2024, p.1). In 2019, UNESCO hosted the International Conference – Language Technologies for All (LT4 All) conference in Paris.

> Everyone should have the possibility to get access to Language Technologies in his/her native languages, including Indigenous languages. The challenge is twofold: (i) preserving culture through language while (ii) allowing communication across languages. Languages that miss the opportunity to adopt Language Technologies will be less and less used, while languages that benefit from cross-lingual technologies such as Machine Translation will be more and more used (Williams, 2019).

Lil’watul Dr Lorna Wanosts’a7 Williams (2019) delivered the above quote during her keynote address, making the point that prior to colonisation, Indigenous peoples had been intergenerationally transmitting their languages without interruption for thousands of years. Seemingly, she says, big tech, has arrived on the scene as the ‘saviour’ of Indigenous languages in a type of overzealous tech evangelism (Williams, 2019). Whilst big tech may not be the ‘saviour’ of Indigenous languages, the assertion that for Indigenous languages to thrive in the future they must exist technologically or digitally to have relevance in the future, is also true (Galla, 2018).

> ... the task is to figure out ... how to maintain our languages from our ways, our perspective, our point of view ... the people today who build technology for our youth ... work with us ... work alongside us. Don't assume that you know. You know a lot about your area of expertise. We know a lot about ours. By working together, we can make it better for all of us (Williams, 2019).

For decades, linguists have been highlighting the need for intervention and resource to save Indigenous and endangered languages and many have seen improvements in technology as a golden opportunity to make significant traction on the goals of language preservation and revitalisation. However, technology, in and of itself, will not address the social injustices and barriers that underly language endangerment and continue to threaten it, nor will it result in widespread uptake of the language (Bird, 2020). Large LMs have the potential to support *lingua franca* and in doing so perpetuate some of the most mainstreamed beliefs, biases, and cultures, sidelining those who are not adequately represented in training data sets (Sangma, 2024). There is real potential for AI systems to create further inequities by overly representing those who have access to social, economic and cultural capital, IT knowledge and higher levels of digital literacy.

Self-determination in AI development

Keeping pace with AI powered technology is becoming increasingly important as there is increased likelihood for those who do not understand it to be left behind, struggling to make sense of a radically changing world (Maini & Sabri, 2017). Many researchers agree it will be essential for all sectors, especially the education sector, to keep pace with AI development and learning (Ahmad et al., 2023) A question for Māori is, how do we decolonise and leverage self-determination through the process? Language loss is the by-product of oppression of Indigenous people by liberal democracies (Merlan, 2009). Colonial governments well understood the role of language in sustaining identity and cultural connection. It is therefore unsurprising, that one of their earliest actions was to take steps to eradicate the language and assimilate the native people into the 'new' culture (Smith, 1999). In AI there is a need to recognise Article 3 of the UNDRIP in supporting Indigenous peoples to "… the right to self-determination. By virtue of that right they freely determine their political status and freely pursue their economic, social and cultural development." (United Nations, 2018, p.8). Indigenous language communities must be the drivers of their language restoration efforts and be active participants (Bird, 2020). One critical area for this leadership and participation is within the contexts of translanguaging and diglossia.

> Translanguaging is the act performed by bilinguals of accessing different linguistic features or various modes of what are described as autonomous languages, in order to maximize communicative potential. (García, 2009, p. 140)

Bird (2020) encourages us to consider *speech* as opposed to the language community, and that there are multiple ways of using language within speech. Code switching may be viewed by some purists as not authentic and unhelpful within language revitalisation, whereas other revivalists like Rawinia Higgins, suggest that even limited use of a language is beneficial, no matter the context or level of proficiency (Higgins, 2015). Code switching results in a 'pedagogical translanguaging' of the Indigenous language and can catalyse and encourage language use (Bird, 2020; Seals et al., 2020). García, (2009) and Najarro (2023), proposes translanguaging is both a skill set and a revolution in the way language is conceptualised, used, and taught. Translanguaging treats languages as fluid, organic and ever-evolving social systems of communication, focusing on communicative practices, linguistic repertoires, and discursive resources. Translanguage speakers may make use of various features of their linguistic repertoire to meet their communicative needs within contexts to meet their identity construction goals. Another way this is demonstrated is through using vernacular and vehicular modes of communication. Diglossia is common amongst Indigenous language communities - using vernacular language for transmitting local knowledge and vehicular language for communicating and participating in wider contexts such as in the global economy or in Western health, education and social systems (Bird, 2020).

As Keegan (2017) points out, this has more to do with linguistic ideology whereas, in reality, speakers of te reo Māori may have little to no regard for social, political or historical fidelity to a defined set of language rules and conventions (Shank Lauwo & Norton, 2023). Anya (2016) likens translanguaging to a 'joint, performative' between speakers, where both can anticipate and fulfil their joint communicative needs by constructing meaning (Anya, 2016). The creation of translingual materials for training AI could contribute much to “whānau reo' a more nuanced, locally responsive, translanguaging pedagogy that is unique to a particular whānau or hapū. Such materials would create improved naturalistic immersive AI models for facilitating intergenerational language transmission with pēpi and tamariki in the home (Seals et al., 2020).

Training AI to meet the everyday communication needs of translingual speakers is an important goal within AI powered speech and language technologies if AI is to assist in contributing to widespread and intergenerational use of Māori language. Bird (2020) argues that there is no place for 'puritanical valorisation' that would see a language reserved for elites, where it is reduced to an artefact or an object on display in a museum; or worse, tokenistic and only spoken during cultural rituals or ceremonies. In acknowledging that translanguaging is part and parcel of language evolution, it is also an important goal for AI developers working within language revitalisation to work to preserve the integrity of orality, oratory and other traditional language forms.

Māori AI in Māori hands

The role of Māori whānau and communities in the development of Māori language revitalisation tools, digital or otherwise, extends to guiding the documenting or recording of language data sets for training. Where no prerecorded corpus exists, this could include documenting through naturalistic interaction, kōrero (talk), tākaro (play), waiata, karakia, kapa haka and other cultural practices. Accurate documentation and development are essential to informing the development of culturally relevant and tailored digital resources for Māori language learning. Without the input, advice and leadership of Indigenous experts to ensure accuracy, the revitalised language may substantially differ from the ancestral one. Always there is a need to include Māori linguistic expertise within AI development for Māori language revitalisation. It should not be the preserve of academics and engineers alone, especially if they are not Māori (Taiuru, 2024a).

As previously mentioned, there are several companies in Aotearoa New Zealand who are using Māori data to train their own AI systems such as Te Hiku Media and Frankly AI (Taiuru, 2024a). Te Hiku Media is a Māori owned company in the far North of Aotearoa that has become a significant player in the field of AI and Māori language revitalisation. As previously stated, Te Hiku have been taking steps to share and licence their data by requiring users to apply for a Kaitiaki licence. To be a kaitiaki in te reo Māori means to be a trustee, a minder, guardian, custodian, caregiver, keeper, or steward. Michael Running Wolf, as cited in Taiuru (2024a) has emphasised the importance of community agency in developing AI with ITM communities.

> We must have our own engineers. We need to have our own computer scientists using the software … We need to have sovereignty over our own data, set the terms and that's the only way to build this AI (Running Wolf, 2024 as cited in Taiuru, 2024a).

AI and rangatahi (young people)

AI holds promise for rangatahi as younger generations Z and Alpha, who are often and justifiably referred to as ‘digital natives’, can readily adapt to and adopt digital technologies to support their language and cultural learning. Digital technologies have the potential to reduce equity gaps in education and help close both knowledge and digital divides by making online learning affordable and accessible for many. It may also contribute to enhanced feelings of pride in cultural identity for young people from experiencing the use of ancestral and heritage languages within modern situations and contexts (Galla, 2018). Studies have evidenced increased feelings of pride towards Indigenous identity amongst students taking part in contemporary language immersion programs (Harrison & Papa, 2005; Reyhner, 2010).

Digital technologies may offer a platform for shared or collective pride through facilitating online communities of learning. Online platforms and apps that are designed by Māori for Māori contexts are much more likely to be culturally appropriate and therefore appealing - supporting increased access, engagement, uptake and patronage (Ovide & García-Peñalvo, 2016; Koole & Lewis, 2020). Moreover, digital apps may advance self-determination by promoting student agency through student-led learning - favouring the leadership and proactive participation of students as opposed to teacher-led learning approaches (Huilcán Herrera, 2022).

Necessity can also be a catalyst for Indigenous digital invention. In 2020, Hemi Kelly, a fluent speaker and teacher of te reo Māori founded 'Everyday Māori', a public te reo Māori Facebook group, during the Covid pandemic. 'Everyday Māori' gives te reo Māori language learners the ability to continue their reo learning journey online despite the restrictions. 'Everyday Māori' is supportive and welcoming to online learners of te reo Māori (globally) regardless of their level of fluency. The site is well patronised, growing to nearly 140,000 followers in 2024. Digital technologies, including AI, have the potential to provide Māori with new, flexible online tools to enable self-determination, but again, they must be ethical, safe and support Māori ownership and control over their own data and content. For AI to truly support RLS for te reo Māori it must have ethical diffusion and practical application for rangatahi.

Reducing other barriers for learners

If innovation in AI can be balanced with ethical use and safeguards then wide application and uptake could help recreate the immersive, synchronised *and* cultural environments that are critical in promoting intergenerational transmission for Māori parents in the home with tamariki. It would also be hugely beneficial to second-language learners and non-Māori wanting to learn the language.

AI can operate across a wide range of platforms, such as hand-held devices, making it accessible and available 24/7 to those with a device and internet access. Improved flexibility and access allow users to learn the language and practice at their convenience without time and travel constraints. AI systems can support an unlimited number of users/learners simultaneously, making group learning possible. It can be reflexive – providing real time feedback with each interaction as an AI is continuously learning and improving, providing iteratively more accurate and tailored responses, fine-tuned to the user (Hayes & Downie, 2024). The provision of immediate real-time feedback can positively impact learning outcomes by providing instantaneous feedback, prompts and suggestions on pronunciation, grammar, and vocabulary usage. This feedback allows learners to identify their mistakes and rectify them immediately, accelerating the learning process and avoiding mispronunciation or grammatical errors becoming 'rigid' or 'fixed' in the learner. AI can tailor language learning content using adaptive

learning techniques by targeting the learning at the learner's level - not over or under- whelming them, which can stifle motivation. Finally, an AI system can use predictive personalisation, by gathering and analysing historical data about the user's preferences to further personalise and improve their learning experience (Hayes & Downie, 2024).

Innate limitations and challenges to developing effective models

Whilst AI has some reflective qualities and capabilities, Lewis and Sarkadi (2024) warn against a machine providing reflection with an 'incomplete mind' that lacks the richness of human cognitive processing to be truly reflective. Language learning is a lot about human interaction which AI cannot replicate. AI cannot always grasp the nuances of cultural context or idiomatic expression. A lack of human connection is telling - AI has a significant limitation in language learning due to its limitations to recreate authentic human interaction. Language acquisition is a complex interactive process that involves neuro, spatial, linguistic, physiological, biological, cultural and educational aspects of communication that AI cannot currently comprehend or replicate. As a result, the immersive experience of AI is currently limited (Campbell, 2023).

Conclusion

The promise of AI after the release of ChatGPT in 2023 by OpenAI was groundbreaking and exciting to a point. The unveiling of generative AI was quickly followed by the 'honeymoon period", with the world holding its breath, awaiting further iterations that could result in sentient intelligence. By mid-2024 the honeymoon was over! The flood of AI generated images and texts are now clogging social media platforms, often difficult to distinguish from 'real' images and narrative – the majority of which is shoddy and substandard. Digital media providers are beginning to purge their sites of AI created content, including big corporates like Microsoft and Google (Sarker, 2022).

LLMs like Bard and ChatGPT are examples of the power of generative AI to provide real-time discourse on practically any and every subject available through the internet. However, over or excessive reliance on AI-based tools might hinder creativity, new ideas and result in a loss of human self-reliance and critical thinking skills - limiting our ability to pivot or adapt to diverse real-world situations and contexts (Sarker, 2022).

There is also a question about equity and a concern that not all learners will have equal access to AI tools due to technological and social disparities, lending to a widening knowledge and digital divide. While some schools and institutions may have the resources to invest in advanced AI systems and software, others may lack the necessary infrastructure or funding to provide their students with the

same level of access (Sarker, 2022). This could mean that students in less privileged communities or schools may be at a disadvantage, missing out on the benefits of AI-powered learning tools and falling behind their better resourced peers. Technology typically becomes cheaper over time, due to things like improved manufacturing processes, wider circulation and broader competition but this still may mean the less privileged could be left behind, relying on older 'handed-down' or previous-generation tech models that may be obsolete, making learning redundant.

The survival of ITM languages will increasingly depend on their presence within new digital media. Humans increasingly communicate and seek information via the internet. If online content is only available in dominant languages, then ITM languages are at risk of becoming 'digitally extinct' (Pasikowska-Schnass, 2020). Sparse data sets and the polysynthetic nature of Indigenous languages are problematic for AI in that there is generally a lack of extensive digital records or written documentation in the language. The words are often morphological, being made up of numerous morphemes or smaller words that have interdependent meaning to convey complex ideas. Because AI has been largely trained on English and other analytic languages, it is uniquely challenged by morpheme-rich content (Martinez et al., 2019).

Technological development has both the means to protect, revitalise and further threaten Indigenous and endangered languages. It is therefore critical that we continue to explore this area of study in collaboration with Indigenous communities so that findings and recommendations can inform future AI development - policy, standards and processes. If data sovereignty and ownership concerns are mitigated, then AI presents an exciting opportunity to, alongside other important revitalisation strategies and techniques, improve language learning and transmission.

Finally, AI-powered language learning platforms collect a large amount of user data. However, many users are concerned about data privacy, security breaches, and ethics relating to their personal information. As AI is embedded into platforms and systems, it will require more data to function effectively. Advanced security systems such as the use of end-to-end encryption must be implemented and kept up to date to ensure that user data is securely protected from potential cyber-data breaches (Sarker, 2022). Federated models that provide improved safety and security for ITM communities should continue to be explored, regardless of their current limitations around use of limited data sets. Future iterations of the *Willow* chip and other quantum computing advances may hold the key to solving some of the inherent issues that exist with FL and hybrid FL.

For all its limitations within the context of ITM language revitalisation, testing and development needs to be considered within Māori language speaking communities (Taiuru, 2024c). We are yet to reach a level where AI is proficient in spoken communication, so its ability to assist in certain

language contexts is currently limited. This is particularly so within the context of supporting the language acquisition of pēpi and tamariki Māori.

Chapter 5: Aligning neural synchrony, rhythm and traditional cultural practices in AI

Introduction

Retaining and developing the neural foundations for language is a primordial underpinning to the enculturation of tamariki Māori. There is increasing evidence that strong links to language, culture and identity positively impact the later academic achievements of rangatahi and self-reported wellbeing of whānau Māori (Mhuru, 2020). There is also growing evidence that exposure to language and culture at home confers additional benefits to tamariki, regardless of whether they participate in Māori medium education or not (Mhuru, 2020; Ka'ai et al., 2021).

Achieving RLS through intergenerational transfer of te reo in the home

The growing role of technology in the lives of Indigenous communities necessitates the constant critique of their purpose, and what they might offer in the way of help or hindrance to the sociolinguistic needs and goals of ITM language communities (Huilcán Herrera, 2022).

Fishman (2007) asserts RLS can only be achieved through intergenerational transfer. To reinstate te reo Māori through 'natural language' transmission, is to recreate the conditions where tamariki grow up with te reo Māori as a 'taken for granted' reality and where parents, grandparents and wider whānau are the primary sources of native language learning (Huilcán Herrera, 2022). Achieving this goal is inordinately difficult in the post-colonial reality of Aotearoa New Zealand, where English language and Western values dominate.

Parents who are fluent in the language should theoretically be able to transmit the language to their tamariki naturally, however, from the Growing up in New Zealand (2015) study we know that regardless of the degree of fluency, less than 15% of parents speak te reo Māori with their children (Growing up in New Zealand, 2015; Te Huia & Maddever, 2022). As previously stated, several barriers exist for fluent speakers that are linked to the historical undervaluing of the language through colonisation. However, another significant barrier is parental understanding of their child's early language development processes and growing cognitive capabilities.

We have seen how AI can offer a range of opportunities to Indigenous communities to support language revitalisation (Galla, 2018). However, to facilitate this naturally in the home, parents must be engaging in regular communication in te reo Māori within the primary language environment of

tamariki. This should be occurring whilst their tamariki are infants and ideally from in utero when they first begin to neuronally entrain to the rhythms of their native language.

The role of rhythm in early language development

From in utero, pēpi can detect and be responsive to rhythms outside the womb and acquire increasingly complex rhythmic abilities over the course of their development (Frischen et al. 2022). Within the first year of life, rhythm continues to be instrumental, enabling infants to segment continuous speech and access other structural linguistic abilities including word order and syntactic structure (Christophe et al., 2001; Johnson & Jusczyk, 2001; Gervain & Werker, 2013; Nazzi et al., 2000). Rhythm is therefore critical to language acquisition. Across languages, rhythmic features highlight fundamental linguistic elements of the sound stream and intra-structural relationships (Lau et al. 2022). This sensitivity to rhythm is evident from only hours following birth when pēpi can distinguish languages from the same rhythmic class as their native language (the language environment of their mothers whilst they are in the womb) and show a preference for these languages over non-native rhythmic patterns or rhythms within phonemes of a different rhythmic class (Mehler et al., 1988; Nazzi et al., 1998). There is strong evidence that native speech rhythms engage an infant's attention early and robustly, supporting their early cognitive development as they increasingly give their neural attention to the phonemes that contain their preferred speech rhythms (Jusczyk et al., 1993; Sansavini et al., 1997; Höhle et al., 2009; Räsänen et al., 2018)

English is a stress-timed language, akin to the languages of many northern European languages including German, Dutch, Swedish, Norwegian and Russian; some Arabic languages are also stress-syllable timed. Te reo Māori is a mora-timed language, sharing many rhythmical patterns and features of the Austronesian group of languages, including Japanese, Cantonese, Malaysian, Hawaiian and the realm languages of the wider Pacific region. Te reo Māori is a younger language within this Austronesian family of languages and is part of the Malayo-Polynesian group that is closely related to Cook Island Māori, Tuamotuan and Tahitian (Otsuka, 2005). Whilst not mutually intelligible, these languages share many of the same grammatical, prosodic and syntactic features.

The relationship between Austronesian mora-timed languages makes sense within the waka migratory journeys of tūpuna Māori who made their way from Micronesia through the Pacific Ocean, leading to their eventual arrival and settlement in Aotearoa (Walter et al., 2017). The ability for infants to show early preference for the rhythms of the languages they can detect in utero has large implications for Māori babies who are born into English speaking environments. If the birth mother and others within proximity of pēpi during the third trimester do not speak te reo Māori, then they may have little to no exposure to the mora-timed rhythms of te reo Māori at this critical stage of their language

development. The developmental window to optimise language acquisition is quite narrow, beginning in utero and lasting for approximately the first 12 months of life (Polka & Werker, 1994; Centre on the Developing Child, 2022). Within this critical window, brain and language development is exponential. Newborn babies continue to shape the neural circuitry for language through a process called declining discrimination, perceptual narrowing or pruning.

Decline in discrimination occurs from as early as 3-months of age, where infants begin to decrease their ability to discriminate or tell apart non-native consonant and vowel sounds that are not used contrastively or often within the native language or languages that they hear all the time (Best & McRoberts, 2003; Krasotkina et al., 2018). Through this process, the neural connections associated with non-native languages are discarded or 'pruned' away. Declining discrimination peaks at approximately 9-12 months of age (Polka & Werker, 1994). This has significant implications for Māori infants as reduction of the early neural capacity to master the morphosyntax[14] of a language has implications for the fluency of second-language learners later in life (Ventureyra et al., 2004; Au et al., 2008).

To ensure intergenerational transmission of the Māori language and to optimise fluency into adulthood, tamariki ideally should have access to the rhythms of te reo Māori in utero and during the first 12 months of life to build and maintain these critical neural capacities. A fundamental process that supports a child's access to speech rhythms naturally, is interpersonal neural synchrony (INS) (Feldman, 2007; Dumas et al., 2011). Research by Ruth Feldman (2007) and others (Markova et al., 2019a; Nguyen et al., 2020) have evidenced cooperation, play, joint attention, affective touch, mutual gaze, rhythmic movement, singing, and speech all enhance INS between infants and caregivers.

Synchronising to the rhythm

INS is defined as the temporal alignment or 'entrainment' of concurrent brain activity between interacting partners or social dyads that support neural, behavioural and physiological synchrony. Neural entrainment occurs when neurons in the auditory cortex oscillate at varying frequencies to speech rhythm. This synchrony, enables infants to extract hierarchical information, including lexical stress, syllabic structure and syntactic patterns (Hoehl et al., 2021). Behavioural synchrony involves the coordination of verbal and non-verbal communication, such as eye gaze and posture, while physiological synchrony encompasses biological rhythms like heart rate and breathing patterns (Feldman, 2007; Hoehl et al., 2021). Hyper synchrony is when brain, behavioural and physiological aspects are all synchronised. In fact, there is a growing body of evidence suggesting that successful

[14] moprphology and syntax relates to the formation rules of language

mother–child interactions rely on hyper synchrony (Feldman, 2007; Lakatos et al., 2019; Dumas et al., 2010; Goldstein et al., 2018; Markova et al., 2019). Markova et al (2019a) argue that INS of brain rhythms may also play a substantive role in caregiver, child coordination, communication, and attachment formation (Markova et al., 2019a).

Thus, the role of rhythm to support language acquisition from the start is clear. At the perceptual level, first signs of rhythmic ability occur very early. Further evidence indicates that newborns already show specific responses in the electroencephalogram (EEG) to changes in sound and are sensitive to repetitive sound patterns and omissions of the downbeat within sound sequences (Kushnerenko et al., 2001; Stefanics et al., 2007; Winkler et al., 2009).

These findings indicate that the predisposition for more complex rhythmic abilities is already present at birth or shortly afterward. This is unsurprising considering full-term babies are born with nearly normal hearing across the sound spectrum (Vogelsang et al., 2022). However, during the prenatal period, while the auditory system is still developing, babies are exposed to a much degraded, low-pitch sound quality within the womb. This is because the sound input they are exposed to is typically slow-wave, low-pitch, low-frequency, created by the muffling effect of the amniotic fluid and surrounding maternal tissues. Thus, the in utero auditory experience of infants is characterised by strongly low-pass-filtered versions of sound streams from the external world (Vogelsang et al., 2022).

The MIT study by Vogelsang et al. (2022), suggests that this form of degraded sensory input may be beneficial, even necessary, for healthy auditory development. This builds on the findings of Graven and Brown (2008), who theorised that the initial stimulation of the auditory system (through speech and music) needed to occur in utero for critical tuning of the hair cells of the cochlea. They suggested control of outside noises and exposure to meaningful speech sounds and music were essential to aiding auditory development (Graven & Brown, 2008). This adaptive feature of infant auditory development confers significant benefits later in life to auditory processing abilities that rely on temporally extended analyses (Vogelsang et al., 2022). Auditory processing of sound rhythm is integral to language acquisition and enculturation.[15] Linguistic anthropologists, Ochs and Schieffelin (1988), addressed the issue of socialisation through language and found that enculturation and language acquisition occur simultaneously. These findings have been further supported by the findings of Perszyk and Waxman (2019) that babies as young as three months old are linking language to core cognitive capacities through object categorisation. They further evidenced that precision in perceptual tuning to the sounds of their native language set constraints on the range of human languages they link to cognition during this early period (Perszyk & Waxman, 2019). Sounds within

[15] learning of sociocultural norms

speech rhythm are not the only mechanisms that support these linkages, non-verbal communication and the use of virtual cues, semiotics and iconography also play a role in early language acquisition (Pearson et al., 2011; Verhagen et al., 2019).

On non-verbal communication

Whilst communication is inherently multimodal (audio and visual) and bidirectional (backward and forward between infant and caregiver), previous studies have primarily focused on verbal communication. However, recent studies into specific non-verbal behaviours of caregivers have found that certain non-verbal cues and gestures such as handing over a toy, pointing, or smiling, predict vocabulary outcomes and social skills in infants (Pearson et al., 2011). In addition, non-verbal behaviours regularly co-occur with speech. Children appear to rely more on visual information when speech is novel (e.g., a label for an unfamiliar object) or something that is unclear (e.g., in the case of referential ambiguity). Studies have found that children use gaze direction, body orientation, and index-finger pointing as cues to learn the reference of novel or ambiguous words (Verhagen et al., 2019). Chong et al. (2003) identified three distinct infant-directed facial expressions, comfort/caring, surprise/interest, and happiness, among Chinese- and English-speaking mothers living in Canada; they theorise that some of these infant-directed facial expressions, in particular smiling, are most likely universal across cultures (Chong et al., 2003; Liu et al, 2021).

However, the trigger that prompts smiling behaviour differs across cultures and all cultures have their own distinctive patterns of non-verbal communication (Maricopa Community College District, 2021). Non-verbal communication modes are an integral part of communicating in te reo Māori. In te ao Māori, some widely known examples of non-verbal communication are the hongi (pressing noses in greeting), pūkana, and mahi ā-ringa (hand gestures that accompany waiata). Gruber et al (2016) undertook a sociolinguistic study of Māori gesture and found some gestures reflect the established forms of pūkana and wiri that are prevalent in common Māori cultural practices such as karanga (ceremonial call) and haka (dance) (Kāretu, 1993). While the ritualised practices of karanga and haka do not directly shape Māori gesture, resemblance suggests that these elements (flat hands, raised eyebrows, widened eyes) are deeply entrenched aspects of a Māori non-verbal style of communication (Gruber et al., 2016).

In a study exploring rangatahi exposure to and use of te reo Māori, Hunia et al. (2020) identified three modes of te reo ā-tinana (body language) that occur in non-verbal communication - te reo ā-karu (communicating with eyes), te reo ā-tinana, and te reo ā-whio (communicating with whistling). Professor Wharehuia Milroy, pointed to other modes of non-verbal communication such as tone, body stance, movement, and facial expression in expressing 'te wairua o te kupu' (the spirit of the

language) at the hearing of the WAI 2336, Te Kōhanga Reo Claim (Waitangi Tribunal, 2012; Hunia et al., 2020).

Te reo ā-tinana includes *kinesics* or gestures, such as head movements, eye contact, facial expressions, eye gaze (looking at or away from a person) and eye talk (for example, pūkana); *haptics* or touch, (such as hongi), harirū (shake hands), awhi (embrace) and mirimiri (rub or massage); *proxemics* or orientation and space (the way people position themselves in relation to others, and the distance between them); and, *vocalics and body percussion* or body sounds and noises such as clapping, clicking, or whistling and other sounds made with the body (for example, takahi (stamping) or pakipaki (clapping)). Hunia et al. (2020) found anecdotal evidence that body language has a structure not unsimilar to that of grammar, syntax of verbal language. Some rangatahi were cognisant of some elements of te reo ā-tinana, referring to them as 'kōrero' and considering them to be synonymous with speaking te reo Māori. Awareness of these broader forms of communicating in te reo Māori may contribute to te reo Māori revitalisation and most importantly to revitalising the nuance and richness of te reo Māori or 'te wairua o te kupu'. Hunia et al. (2020) note these non-verbal forms of communication were clearly identifiable amongst rangatahi as an integral everyday part of how they communicate with each other when speaking te reo Māori. Further studies to explore at what stage of development these distinctly Māori modes and styles of non-verbal communication appear in childhood would be highly valuable in the context of the current study.

Transmitting the rhythms of te reo Māori through oriori and other rhythmic forms

A traditional mechanism for optimising transmission of language to pēpi in utero, during the birthing process and throughout the early stages of their development was the singing of oriori. Oriori are a subset of the traditional genre of waiata called, mōteatea - highly rhythmic chants or laments that provide rich narrative and genealogical knowledge of whakapapa, Māori tribal connections, histories, language, customs, beliefs, and ancient tikanga or lore. In mōteatea we hear stories of birth, death, love, war and important geographical features, including ancestral names and the names of wāhi tapu (sacred sites) (Cable, 2023). Oriori are rich in imagery, poetry, simile and metaphor. Sadly, this ancient form of communication to infants was all but lost along with the language. Following the introduction of the 1907 Tohunga Suppression Act, tohunga (specialists or expert knowledge holders) within the tribe, abandoned the transmission of these sacred art forms, taking their kura huna (hidden gifts of ancient wisdom and knowledge) with them to the grave when they passed over into te ao wairua (spiritual realm). Only a few illustrious examples of traditional oriori remain, some of the most famous amongst these are, *Nau mai e tama* composed by Tuhotuariki; *Pō Pō* composed by Enoka Te Pakaru; *Kia tapu hoki koe* composed by Hinekitāwhiti; *Te Ua o te Rangi* composed by Ripeka Paiatehau and *E tama e* composed by Te Māperetahi (Tikao, 2023).

From the mid-1920s and over a period of forty years, with the help of Pei Te Hurinui Jones and later, Hirini Moko Mead (as translators), Tā (Sir) Apirana Ngata, faithfully began recording and documenting tribal mōteatea which would later be published in a four-volume set of books, *Ngā Mōteatea,* for the Polynesian Society (McRae & Jacob, 2011). Many of these mōteatea have now been reclaimed and revitalised through kapa haka. They continue to be performed as a living art form and a profound source of knowledge, a puna (pool), for hapū and iwi to draw from. The linguistical content has been especially valuable to revitalising dialectical, lexica grammatical and syntactic elements within local tribal language.

Te whare tangata or womb is the pre-natal and first wānanga (approach to, or place of learning) of the child where they lay the foundations for their psychosocial and physical functioning (Tikao, 2023). Composer and language expert, Paraone Gloyne (2023), rejects the notion that oriori were a form of lullaby (a song sung to soothe a baby to sleep). Gloyne (2023), maintains that because oriori were composed specifically for infants, they were incorrectly interpreted as a lullaby by early ethnographers (i.e., Elsdon Best and Percy Smith), because it was the closest approximation they could find to anything like it within a Pākehā Western context or worldview. This misinterpretation has unfortunately become widely entrenched. In fact, oriori were designed to do the exact opposite, which was to *whakaoho* or awaken a child's wairua (spirit) and mauri (essential life force) to their language, ancestry and tribal heritage, literally 'feeding' their hearts and minds (Gloyne, 2023).

Ngāi Tahu historian Samuel Robinson (2005) claims oriori provided an iteration of the Māori creation narrative delivered as an illumination to the child in the womb about his or her sacred origins and impending birth. Orioiri were a literal vocal map guiding pēpi through the many sacred phases of their journey from Te Kore (void) to Te Pō (night or darkness), to Te Whaiao (space between Te Pō and Te Ao Marama, sometimes used to describe the birth canal), to their arrival in Te Ao Marama (the world of light) (Tikao, 2023).

The late Ngāti Porou rangatira, Amster Reedy (2009), was instrumental in reinstating oriori and karakia within his own whānau, hapū and iwi - delivering wānanga to teach and support expectant parents to compose and chant their own oriori to their pēpi in utero. Reedy (2009) was an authority on the subject, particularly in relation to his expertise on the well-known oriori, *Te Oriori ā Tūteremoana* composed by the tohunga, Tūhotuariki of Ngāi Tara in the mid-sixteenth century. This renowned oriori is impressively long, linguistically rich and comprises eight verses - each approximately 2-3 minutes in duration. Reedy (2009) espouses this famous example of traditional oriori was a compilation of the most intellectual minds of the time.

Mnemonic devices, semiotics and iconographic aides in language transmission

As Māori is an oral language, traditionally tūpuna relied on memory to preserve mātauranga and history. Melody and rhythm were an integral element within incantations and song, with the highly rhythmic patterns of karakia and mōteatea acting as a mnemonic device (McLean, 1996). Other traditional mnemonic or memory aids included rakau papatūpuna, (notched sticks used in the recitation of whakapapa); tohu whenua (natural landmarks such as awa (river/s) and maunga (mountain/s)); iconographic patterns woven into whāriki (woven mats) or tukutuku (woven panels), pou whakairo (carved posts or figures), tāmoko (traditional tattoo) and kōwhaiwhai (painted rafters) inside the wharenui (ancestral house). All of these traditional art forms acted as mnemonic tools to recall and recite the kōrero or narrative associated with them.

Within a traditional Māori epistemology, knowledge is viewed as something tangible that can be stored at various locations or imbued through spoken word 'into' places or objects (Salmond, 1982). The term, pakiwaitara (stories or narratives) phonologically can be translated as, the 'paki' (anecdotes or stories) pertaining to 'wai' (water or who/whom) is within the tara (wall/s). The use of water in the context of identifying people relates to whakapapa identity through links to the nature of water or fluid in both the birthing process (reproductive and amniotic fluids of an infant's parents) and through geographical features, that locate a person's identity in relation to their tribal location in proximity to a body of water – awa or moana. These fundamental understandings are metaphorically represented and referenced through the rich patterns contained within the walls of the wharenui or ancestral house depicting stories of tūpuna Māori, their antics, deeds, whakapapa and histories. The great body of personal and tribal information contained within semiotic and iconographic features within built structures and te taiao aid in the establishment and retention of Māori tribal identity, knowledge and histories. For survival, these rich stories and anecdotes were faithfully recorded in the above array of artifacts and cultural forms, committed to memory, recalled and recited down the generations (King, 1978).

The use of rhythmic mnemonic devices in traditional cultural transmission were common not just to Māori but throughout the Pacific. The performance of the *Fa'ataupati*, in Samoan culture, also known as the 'slap dance', consists of rhythmic clapping and slapping on the body (Ong 1982). Repetitive rhythm is also inherent in the pedagogical methods employed in traditional wānanga style learning of waiata and pūrākau (origin stories) between kaiako (teacher) and tauira (student) for memorisation. Mahuika (2012) notes when interviewing tauira Māori engaging in traditional wānanga,

> The rhythmic and mnemonic 'patterns' were not specifically addressed … nevertheless, they did note the process of remembering as a repetitious activity that mimicked the tone, phrases and orality of their teachers and mentors … oral dimensions of songs and stories

> were 'modelled' and practiced for hours every week over a select period (Mahuika 2012, p.298).

Repetition and accuracy were critical to the teaching style incorporated into traditional Māori teaching methods or 'wānanga'. In pre-colonial times, close attention was placed upon the accuracy of transmission. Tauira had to memorise and recite faithfully, without error, what they had been taught by tohunga. Memorisation and recitation were highly regarded skills that were taught within an apprenticeship style wānanga to nurture young orators (Murphy, 2015). Thus, reliability of transmission required learning methods that emphasised repetition and strategies for memorisation. Strict codes of conduct for retention were achieved through cultural norms connected to the observance of tapu (sacred or restricted) and noa (ordinary or unrestricted), as well as mana and mauri (King, 1978). Sacred knowledge was (and is), therefore, a feature of Māori ritual oral transmission guided by specific tikanga or cultural and social conventions (Murphy, 2015).

Sensory deprivation in visual and auditory processing

The process of language and knowledge transfer was also designed to maximise learning, memorisation and recall. Often wānanga were held in the dark, creating a form of visual deprivation. Relying on hearing alone, helped the listener to 'tune in' to the sounds within the whare (house). Mōteatea were often transferred through this methodology, with the kaea (leader – usually in haka or waiata) of the chant setting the tone and maintaining the rhythm through repetition. Those listening would listen intently and in silence, concentrating on memorisation of the kupu (word/s), rhythm and structure, joining in as their confidence grew.

> They [the elders] would wait late at night at the marae, until late and then the lights went down, all the lights were switched off, tilly lamp, candles, they blew it out and the room was in total darkness, and they'd practice on us as little children for the retention of memory. They'd practice talking so that we can beam in with our ears and we were more comprehend[ding] and [attentive to] the information because there was no visibility of our eyes to contaminate our brain, it was totally clear (Mahuika, 2012, p. 279).

Shearer (2018) recounts a kōrero between Tūhoe tohunga, Hōhepa Kereopa, and the Pākehā historian, Paul Moon, discussing the notion of listening as a process of engaging vibrations beyond the human register of hearing. The notion being that the term whakarongo (listen) pertains to all other senses (other than sight) not only hearing. Tuning into these vibrations conveyed additional information to the listener, especially in the case of low frequency vibration that could be perceived through the body (Shearer, 2018).

Recent studies into sensory deprivation and sensory integration evidence additional benefits to . inhibiting stimuli to the visual cortex to enhance auditory processing. After a period of visual

inhibition, increased functional plasticity was detected in the primary auditory cortex of subject participants - enabling improved sound processing of the high-frequency sound stream (Jendrichovsky et al, 2024; Petrus E. et al., 2015; Sabourin et al., 2022).

Linguistic decolonisation

Pre-colonial practices of tūpuna Māori to support language transmission to infants closely algin to the very recent neuroscientific understandings of the important role rhythm plays in early brain and language development. This extends to the use of sensory deprivation to optimise auditory processing and early auditory development. Further exploration of these ancient techniques and revitalisation of them to support best-practice dyadic infant/child and adult communication would be valuable endeavours, especially within the context of te reo Māori revitalisation. Revival of ancient practices is a decolonising praxis – both unlearning the widely perpetuated, entrenched 'myths' of Māori sociolinguistic traditional practice, i.e. oriori are lullaby and reclaiming the knowledge that oriori are highly sophisticated rhythmic, mnemonic transmission tools that optimise INS, language learning and enculturation. Strengthening the links between language, culture and identity can be emancipatory for Māori, reinstating a sense of pride in Māori identity, which in-turn catalyses further revitalisation and increased self-determination.

Hana O'Regan (2016), argues that whilst the eradication of the Māori language was a tool to dismantle Māori cultural identity, the restoration of it can be a tool to reclaim and affirm cultural identity, culminating in tino rangatiratanga (self-determination or sovereignty). O'Regan (2016) outlined her theory through two interrelated models of linguistic colonisation and decolonisation - both models comprising 5 progressive stages of impact. In the model outlining detrimental impact, Māori shifted from being self-determining pre-colonisation to internalising negative stereotypes through linguistic colonisation and assimilation to the dominant language and culture. In the converse condition, Māori have, through linguistic de-colonisation and the revitalisation of language and culture, shifted from powerlessness to reasserting their mana (O'Regan, 2016).

Traditional and contemporary learning approaches

As aforementioned, the collective social structure of early Māori society provided for the ease of intergenerational language transmission and enculturation of pēpi to Māori social and cultural norms. This was made possible in that pēpi and tamariki were surrounded by their wider whānau, including their elders who were traditionally the main knowledge holders within the tribe. With many parents, grandparents, and older siblings and cousins, a child's sense of community and social connectedness was deepened through the collective caring and provision of guidance to pēpi and tamariki (Herbert,

2002). As the child developed, te reo Māori transmission was further aided through traditional focused pedagogical frameworks called ako (teaching and learning) and wānanga within tuakana-teina (older and younger (respectively) siblings, cousins, peers of the same gender) social learning dyads.

In Māori society the concept of ako is premised on the idea that all people have valuable knowledge to share, and that learning takes place as kōrero or conversation between equals, rather than via expert-led instruction (Bishop et al., 2007; Petersen, 2021). As a verb, ako means both to teach and to learn, it is both holistic and reflexive. Ako emphasises the reciprocal responsibility within learning dyads through sharing an idea, knowing, experience, time, space and energy (Cherrington, 2012). It should also be noted here that tuakana-teina relationships were traditionally used to denote age within same gender relationships. This made sense in pre-colonial contexts when being older was synonymous with having spent many more years learning within the whare wānanga (house/place of higher learning). However, in contemporary times, where the natural flow or transmission of knowledge has been interrupted, a tuakana may be younger in age than their teina but have superior knowledge and therefore the use of the term 'tuakana' can be used to identify someone with superior skills or knowledge. The complex, contextual nature of these relationships is further explained in the next section.

Ako commonly was the mode of learning within the whare wānanga (house/place of higher learning). Whare wānanga literally translates to house or place of higher learning and has been described as a dynamic learning environment, a physical place, conceptual space, a school, an act, and a form of governance, practice, and pedagogy (Mahuika & Mahuika, 2020). Wānanga as practice was embedded in, and shaped by, local knowledge, language, place, people and tikanga. Traditional whare wānanga were governed by strict lore or tikanga, accessible only to a chosen few. In the post-colonial contemporary context of Aotearoa, wānanga has been revitalised and has evolved to be a Māori Indigenous practice methodology, space, place, and method of knowledge construction and transmission (Mahuika & Mahuika, 2020).

The vertical transmission of language, cultural knowledge, norms and nuances (i.e. from parent to offspring) is a typically robust mode of cultural inheritance within nuclear Western contexts. However, within Māori tribal society, tamariki also benefited from horizontal or peer to peer and oblique (teacher to student) modes of transmission (Murphy, 2015). The channel of information flow is, therefore, not limited to a single or one-way, didactic directional mode of inheritance but distributed across a variety of channels. Pēpi and tamariki learned not only from their parents, but also from their siblings and other whānau members through everyday observation, encounters and interactions (Murphy, 2015).

> Mā te Tuakana kā tōtika te Tēina. Mā te Tēina kā tōtika te Tuakana. From the experienced learner the in-experienced learn the right way to do things; from the in-experienced learner the experienced learn the right way to do things (SLIANZ, n.d. p.1).

The above whakataukī (proverb) accurately reflects the mutually beneficial, non-mutually exclusive, horizontal, reciprocal and egalitarian nature of tuakana-teina relationships - where an older or more expert tuakana helps and guides a younger or less expert teina in their learning. Whilst the teina is learning new knowledge from the tuakana, through the reciprocal process of ako, the tuakana is strengthening their pre-existing knowledge, building upon it through ongoing exploration, repetition and reflection. In the context of language learning this would mean a more proficient or fluent speaker or tuakana, modelling, mentoring and guiding a less proficient speaker, or teina. Again, these roles were traditionally and more contemporaneously interdependent and interchangeable depending on context – the learner assuming the role of teacher and vice versa.

Perhaps the closest approximation of a tuakana-teina dynamic for learning language within Western concepts of learning dyads would be Leane Hinton's Master-Apprentice (MA) model of learning which emerged in 1992 (O'Regan, 2016). The model was first proposed as a response to the predicament of the endangered languages of the First Nations people of California. The model relied on a single fluent speaker being peered with a learner, rather than a community of speakers (O'Regan, 2016). The MA model demands strong fidelity to the Indigenous language between the master and apprentice, where the non-Indigenous, dominant language is never deferred to, even for clarification. Apprentice learning can be a powerful mode of social learning, promoting the reliable re-acquisition of complex language skills from a strong language model (O'Regan, 2016).

Traditional methods and approaches

Arapera Royal-Tangaere (1997) explored the similarities and differences between the methods of teaching within traditional oral Māori pedagogy and apprenticeship style learning. Royal-Tangaere (1997) asserts that traditional Māori pedagogy involved a much more holistic structure of learning, by incorporating both pūrākau and utilitarian knowledge into a working whole. Knowledge of taiao or local ecology were embedded in pūrākau type narratives. Knowledge about cosmology, whakapapa, tribal history, seasonal changes and local resources were interwoven within a traditional ancestral pedagogy. Tangaere (1997) likens learning to the symbolic designs of the Poutama (steps) - the staircase pattern used in raranga, traditional weaving and tukutuku, lattice work (Royal-Tangaere, 1997). The Poutama represents Tāne-nui-a-Rangi's (deity in Māori theology) ascent to te tihi o ngā rangi (the top layer of the heavens) to retrieve ngā kete o te wānanga (the three baskets of knowledge). Analogous to the theory of scaffolding in knowledge building, a stable platform of proficiency must be attained before proceeding to the next. The Poutama represents stages of a learning journey, with

natural places to pause, reflect and consolidate learning, before advancing. Royal Tangaere (1997) underscores the connection between traditional Māori pedagogy and Vygotsky's (1978) Zone of Proximal Development, with its underlying theory of cognitive scaffolding (Royal Tangaere 1997).

In the home, pou reo (highly proficient language speakers) make conscious decisions about which language to use in which context. A pou reo can be a major influencer of language choice for pēpi and tamariki although this is not always the case (Hutchings et al., 2017). As with the reciprocal and mutually beneficial process of ako within tuakana-teina relationships, even the youngest members of a whānau can exercise agency over which language(s) they choose to use (Hunia, 2016). Ormsby-Teki et al. (2011) speak to the agency of the child within their whānau, "For some families, it is the child who provides the initial language platform for the whānau" (Ormsby-Teki et al., 2011, p.51).

The Te Ahu o te Reo Te reo Māori in homes and communities: Overview Report, published in 2017, indicates that tamariki positively influence family members' use of te reo Māori (Hutchings et al., 2017). Other influences that have a positive effect on the choices of adults and older tamariki to speak their native language include when the kaupapa (topic or theme) is culturally connected; when wanting to have a private conversation; or when both speakers have an established relationship in their heritage language (Olsen-Reeder, 2017). Hunia (2016) found that the language choices of very young Māori children are influenced by multiple factors, however, the more adults engage with tamariki in te reo Māori the more likely they are to use it (Hunia, 2016).

For the majority of whānau Māori, te reo Māori is not the language of choice at home. Reflecting on the Growing up in NZ study, we know the multiple and complex factors that create barriers to speaking the language in the home with tamariki. Tamariki Māori often have no choice as the only language they have access to is English, limiting their agency in influencing the home language environment. However, there is evidence that tamariki who access te reo Māori outside the home, within Māori medium education, can influence the language choices of their parents, grandparents and wider whānau (Ormsby-Teki et al., 2011).

Kōhanga kids can catalyse te reo revitalisation in the home

> Ko te reo Māori te iho o te ahurea, ara, ko te mātauranga me ngā āhuatanga katoa o tea o Māori. The Māori language is the lifeline of our culture of which knowledge is the cornerstone for a Māori world view. (Ka'ai (1995), p. 37, as cited in McClutchie Mita, 2021).

According to Ka'ai and Higgins (2004), within Māori medium education, Kōhanga Reo and Kura Kaupapa Māori are a natural language pathway and educational progression. Wharekura (Māori tertiary education institutions) were established in the 1990s, strengthening this pathway and creating

an educational continuum ‘in the language’ for graduates of Te Kōhanga Reo and Kura Kaupapa (Morehu, 2009). The primary objective of the Kōhanga Reo was to create immersive language environments for tamariki, where te reo Māori is the only language of instruction (Ka’ai, 2004). From its inception, Kōhanga Reo became the flagship for Māori language revitalisation - marking the beginning of a revolution within the education system and a renaissance of Māori cultural revival (Morehu, 2009). Since the first Te Kōhanga Reo opened in 1982, over 50,000 tamariki have attended Kōhanga Reo (Care for Kids, 2017), resulting in 2nd and 3rd generation second speakers of the language; some of these graduates having gone on to raise their own tamariki as first language speakers (Ka’ai, 2017).

Tamariki who attend Kōhanga are often the catalyst for their parents te reo Māori learning journeys. Parents and grandparents who were admonished and beaten for speaking te reo Māori embraced the Kōhanga movement, desperate to not see their own tamariki and mokopuna bereft of their language. Morehu (2009) attests to the struggle of kaumātua (elders/grandparents) and mātua (parents), namely mothers, who spearheaded the grassroots movement of Kōhanga Reo, many of them possessing little or no te reo Māori themselves. Determined to support their tamariki in their language acquisition, many attended night classes to strengthen their own language skills. Parents grew their own reo alongside their tamariki, creating linguistic consistency across education and home environments (Morehu, 2009).

Regardless of parental aspirations and efforts to provide their tamariki access to te reo Māori, only 17% (7,793) of tamariki Māori attended Kōhanga Reo in 2023 - a drop from 19% in 2015 (Te Mahau, 2023). Finding new ways to expose tamariki Māori to the critical rhythms of te reo Māori (especially early, from in utero and in the home) is essential for their neural, physical, psychological, spiritual and cultural development as Māori and for their sense of identity and wellbeing. Options to expedite and gain real traction in RLS and intergenerational transmission remain a holy grail in ITM language revitalisation. If AI technology is to aid the restoration of ITM languages it must be able to integrate and incorporate both traditional and contemporary understandings of approaches to early language transmission to aid language uptake in the formative years. Integrating both traditional and contemporary understandings of the role of rhythm in language and brain development is an important goal in AI development for language assistive technology.

Conclusion

This chapter has highlighted how fresh understandings in infant neuroscience have identified the important role of rhythm to facilitate neural entrainment and INS. There has been a longstanding

awareness amongst researchers that infants can detect and react to the rhythms of human speech long before they understand the sounds of language or the meanings of words. As early as 1988, research demonstrated that newborns at 8-weeks old could discriminate between their native and any other language using rhythmic cues (Mehler et al., 1988; Stanborough, 2024). Speech rhythm information is the ‘hidden glue’ underpinning the development of a child’s native language. Rhythmic information relating to rhythmic class, the stress or emphasis on syllables and other prosidic features – intonation, pitch and tempo, are key to language learning (Ní Choisdealbha et al., 2023). Feldman’s (2007) hyperscanning research and other infant neuroscientific exploration (Nguyen et al., 2020; Nguyen et al., 2023; Markova et al., 2019b) evidences that babies begin neural entrainment to this rhythmic information early, even from in utero. Having access to the Mora-timed rhythms and prosodic features of te reo Māori is vital for pēpi Māori to begin laying down the neural circuitary they require to be fluent in their language.

There is significant alignment and congruence between traditional Māori language transmission practices and nascent neuroscientific discoveries in infant language development. Rhythmic information conveyed through the repetitive, low frequency traditional mnemonic mechanisms of tūpuna, such as those found in oriori, may provide additional benefits outside of language acquisition. These extended benefits include enhanced neural entrainment to support INS, high-frequency sound inhibition to support the fine tuning of the auditory systems of newborns and visual sensory inhibition to support enhanced focus and memorisation.

Taken together, research into the critical links between rhythm, auditory processing, sensory modulation and deprivation, INS and traditional cultural practices within infant language and cognitive development could help to inform neuro, social and culturally responsive AI to accelerate the early acquisition of te reo Māori. Pedagogical approaches such as MA also align closely with traditional pedagogies such as wānanga and ako. The reclamation, revitalisation and integration of these traditional approaches within contemporary pedagogies and language transmission strategies should also be key considerations within AI design projects that focus on designing language assistive technologies to support infant uptake of te reo Māori within the home environment.

Chapter 6: Integrating mātauranga Māori and diverse knowledge streams in AI to enhance early te reo Māori acquisition

Introduction

For Māori and other ITM language communities, being able to progress the goals of revitalisation and reassert cultural identity through intergenerational transmission, is an act of decolonisation (Leonard, 2017). Social identity is materialised, strengthened and maintained through language exchange and social interaction. Speaking one's 'native tongue' is a marked identifier, both for self and others, as belonging to a particular ethnic group or tribe (Bucholtz & Zimman, 2019). Huilcán Herrera (2022) proposes that our linguistic preferences and practices are integral in shaping our social and cultural identity and reality. These linguistic preferences are shaped in utero and in early infancy.

Indigenous languages are indivisible from the socio-cultural, political, historical and geographical context from which they arise and more importantly, from the context in which they can continue to thrive. It is therefore unsurprising that some Indigenous peoples view one's identity and ability to speak their native Indigenous language as synonymous. This view is particularly true of the Quichua[16] people of South America. Regardless of the known impact of colonisation on the language, identity and culture, people who are unable to speak Quichuan language are often viewed as outsiders (Bucholtz & Zimman, 2019).

There is a growing gap in the accessibility of Māori medium early immersion learning options for whānau Māori owing to a decline in the number of Kōhanga Reo and a growing demand for immersion programs (Ministry of Education, 2023). Accessibility issues persist, particularly in rural or less densely populated areas (Rau & Ritchie, 2011). AI technology that can enhance interaction with tamariki in te reo Māori could be invaluable in improving access to te reo Māori options for whānau who experience these barriers. For example, it could support kaiako within English-medium early learning centres to use more te reo or bridge the gap by assisting parents to create a more immersive te reo Māori environment at home. Bird (2020) maintains that the presence of Indigenous languages in the digital world can represent a point of access for young learners, who as digital natives, can more readily adopt them (Dołowy-Rybińska & Hornsby, 2021).

Integrating neuroscientific insights with mātauranga Māori in AI

[16] Quichua is a stable Indigenous language of Argentina. It belongs to the Quechuan language family, particularly in the geographical area of Argentina, Bolivia, Chile, Colombia, Ecuador, and Perú. It is an endangered language despite a large population of about seven million speakers (Ethnologue, 2022).

Informing affordances in the design of AI assistive language tools to optimise their utility, application and dispersal within early acquisition contexts is an important goal (Ramaul et al., 2024). Integrating both traditional mātauranga Māori and Western sociolinguistic practices could build these affordances to optimise te reo Māori acquisition outcomes of tamariki, mātua and whānau. Catering to Māori language learning communities requires an AI to be savvy, nuanced and operate fluidly and responsively across a range of language contexts. Māori language contexts can be dynamic across a linguistic repertoire, incorporating mono, bi, multi, translingual, code and style switching.

An AI tool integrating diverse knowledge streams could also support mātua, kaiako and whānau with limited te reo Māori to revitalse traditional Māori approaches to language transmission alongside tamariki and pēpi. Māori pedagogical concepts and approaches such as tuakana-teina, ako and wānanga could be integrated into AI to support reciprocal and horizontal learning – creating culturally authentic and immersive language learning experiences for end users. Revitalising oriori, mōteatea and the use of other mnemonic cultural aides embedded in iconicity and iconography can support the natural transfer of language and knowledge to pēpi from in utero. Indigenous communities require support from elders, linguists, data sovereignty experts, resource and technology developers (working together) to safely document, record, store and mine their language data for model training (Huilcán Herrera, 2022). Language communities should be viewed as integral members of the design/development team within these programmes of work to achieve culturally informed, safe AI tools for language revitalisation (Genee, 2018; Junker, 2018; Rice, 2018).

> Over the years we have recorded the speech of more than 40 Māori speakers for our study, half of which are kaumatua or kuia and highly respected orators. The language as spoken by these current elders is highly valued, and many younger speakers consider it a compliment if they are told they sound like an elder (Keegan, 2017, p.1).

Finally sociolinguistic knowledge is vital in the mix of AI design for language revitalisation. Translanguage speakers make strategic use of various features of their linguistic repertoire to meet their communicative needs in particular situations and contexts or to meet their identity construction goals (Garcia, 2009; Seals et al., 2020). Training AI to meet the everyday communication needs of translingual speakers is an important goal for AI powered speech and language technologies if it is to assist in contributing to widespread and intergenerational use of te reo Māori. Within any technological development project, involvement of local community is critical to success and there is evidence that the most successful technological projects involve a wide range of participants (Coronel-Molina, 2019, p.96).

Facilitating transdisciplinary perspectives and approaches in AI

Transdisciplinary relates to, but also differs from, multidisciplinary and interdisciplinary approaches in small to significant ways (Renn, 2021; Cao, 2023). Cao (2023) outlines the differences in the approaches as follows,

- Multidisciplinary approaches are independent or loosely coupled for specific tasking and problem-solving.
- Interdisciplinary approaches interoperate and interact with each other for blended, cooperative or joint tasking and problem-solving; and
- Transdisciplinary approaches transform each other and integrate for systematic, integrative to new tasking and problem-solving (p.125).

Multidisciplinary, interdisciplinary, and transdisciplinary approaches are often interrelated, mixed or combined to address complex problems (Bryon, 2017; Cao, 2023). Real world problems are vastly complex and cannot be solved by a single discipline. Instead, a combination of a variety of perspectives from diverse fields is necessary to developing and operating AI research programs. Implementing a transdisciplinary approach requires close cooperation of different disciplines and their interactions within a holistic, integral system incorporating diverse world views and perspectives (Cao, 2023). Transdisciplinary AI supports 'out-of-the-box' thinking beyond methodologies and developments that are based on data-driven, model-based, statistical, shallow and deep learning hypotheses, Transdisciplinary AI draws from multiple intelligences and reflects the complexities inherent in human cultures, societies and their creations (Cao, 2023). Implementing the ultimate AI goals of developing natural human social intelligence requires significant 'beyond thinking,' and paradigm and methodological shifting (Cao, 2023).

Indigenous language and cultural expertise are indispensable within AI projects that are intended to support language revitalisation within Māori and other ITM communities. A unique challenge for AI designers working in a Māori context will be perfecting speech language models using limited data sets to exact Māori speech recognition in NLP. Another challenge will be mastering complex sound combinations within te reo Māori speech, like 'ng' or rolling 'r's. Transcribing audio 'faithfully' into text without a rudimentary understanding of the nuances within Māori language and pronunciation will potentially result in the elimination of non-errors and creation of false errors in the documenting of natural communication. This is particularly important as false errors could forever misconstrue meaning, lending to future miscommunication and confusion. Without the expertise of te reo Māori authorities, AI developers are bound to repeat interpretation errors of the past. The misnaming and misinterpretation of Māori words and place names has had serious historical consequence for Māori, especially in Crown Treaty relations. Nowhere is this better demonstrated than through issues of

interpretation over the meaning of Māori words that convey complex cultural concepts in Te Tiriti o Waitangi.

Creating a conceptual model to guide a Māori transdisciplinary approach in AI

In 2020, a small AI project began at the Auckland University of Technology (AUT) to explore the potential of leveraging AI in early te reo Māori language development. The project emanated out of the desire for a North Island iwi to maximise the early years' window of child development to strengthen links to language, culture and identity. Professor Tania Ka'ai, brought together a small team, comprising Māori language revitalisation, early oral language, early childhood education and AI expertise. The team engaged with a range of stakeholders including end users - Māori parents, kaiako, hapū and iwi.

Over time the need for increasingly specialist levels of expertise grew the team exponentially to include experts in te reo and tikanga Māori, Māori sociolinguistics, and Māori data sovereignty and security experts. The drive to ensure the vision of AI development for Māori communities remains Māori driven and led, required a model that could ensure integration of these diverse knowledge streams. Professor Ka'ai proposed fashioning the model on Te Wheke – the octopus. Te Wheke was discussed and explored as a potential model to represent the multifarious nature of the project. Whilst the central concept resonated and made sense culturally and practically, the model was not developed further at that stage. Therefore, some of the more nuanced aspects and features of the Te Wheke Model remain unidentified, defined and interpreted. The opportunity for this thesis, is to identify and define additional aspects that strengthen the model and facilitate its practical application.

Developing the key features of the Te Wheke Model for Transdisciplinary AI

To authentically develop the model further, it is first important to define the process of the model's genesis and synthesis as being constituted through a 'by and for Māori' led process. The originator, Professor Ka'ai is of Ngāti Porou descent and has entrusted the model for development to the author who is of Ngāti Kahu and Ngāti Te Ata descent. This transfer ensures the cultural integrity of its grounding and future development through ensuring it remains in Māori hands. Using Rangihau's Māoritanga Model as a guide, the author understands this to mean that having whakapapa Māori is central to the research process to ensure authenticity, cultural integrity and academic rigour. Aroha, which translates to love or care, is also central within Rangihau's model. Embarking on this research endeavour is an expression of aroha for the Māori language. Creating a model for transdisciplinary AI

is about ensuring that the right mix of skills and knowledge are invested in developing AI for use with Māori language communities.

Ka'ai-Mahuta's Tienga model, (2010), proposes that concepts within te ao Māori are not to be seen in isolation of one another, but as an integrated, woven whole. This model goes to the heart of designing a model for transdisciplinary AI because it represents both the independent nature of each strand of knowledge or discipline, respecting their unique attributes and contributions but emphasises that in order to create something that is structurally sound and meaningful, the weaving or integrating of each strand is a critical step.

Finally, Taituha's (2012) Te Kawau Māro model, reminds us of the archetypal nature of Indigenous constructs and that as Indigenous peoples we share common histories, languages and ways of thinking and knowing that can reaffirm and strengthen our knowledge systems, especially within the language and cultural revitalisation process. Te Kawau Māro also reminds us that our tūpuna were entrepreneurial in their endeavour and not adverse to learning from other knowledge systems, including Western epistemologies. The three models (taken together) provide the crucial framing to taking a transdisciplinary Māori approach to advancing the Te Wheke Model for Transdisciplinary AI further by gaining a fuller, holistic understanding of Te Wheke. This requires researching both Māori and other Indigenous people's traditional relationship with wheke alongside the Western marine-biological understanding of octopus and their characteristics.

At Karaka Point, near Picton at the top of the South Island of Aotearoa, stands a carved pouwhenua (boundary marker) depicting Kupe, the discoverer of Aotearoa New Zealand, who pursued a giant wheke called Te Wheke o Muturangi to Raukawa Moana (Cook Strait). Raukawa Moana lies between Te Ika a Māui (North Island of New Zealand) and Te Waipounamu (South Island of New Zealand). Numerous place names around the Marlborough and Queen Charlotte Sounds are dedicated to Kupe's pursuit and battles with Te Wheke o Muturangi. For example, the Island of Arapaoa is named after the killing blow that Kupe delivered to Te Wheke o Muturangi (Lewis, 2017). Other stories of Te Wheke o Muturangi talk of its size, strength, intelligence, ability to outsmart its opponents and its influence over the ocean and sea life. Once thought of as a bad omen, Te Wheke, has come to represent a cultural symbol of journeying from distant homelands. Te Wheke also features in prominent whakataukī. One referring to its tenacity and ability to attach itself firmly to rocks and other objects, 'e tia me te wheke e pupuru ana' (hold on like an octopus); and another relating to its tendency to give up once caught, 'kaua e mate wheke, me mate ururoa' (do not die like an octopus, fight like the great white shark) (Wassilieff and O'Shea, 2006). In other cultures of the Pacific the octopus represents relationships, with its eight tentacled arms extending to the farthest reaches of the Polynesian triangle,

connecting Aotearoa (New Zealand), Hawai‘i and Rapa Nui in one unified body (Carrasco, 2019). Other stories refer to them as guardians of the sea and symbols of navigation.

There are some clear parallels to draw between the traditional Māori story of Te Wheke o Muturangi, other Pacific narratives and the octopus that are found in the waters around Aotearoa New Zealand and the Pacific Ocean. Two of the largest species of octopus are found in the waters of Aotearoa, including the giant gelatinous octopus which grows up to four meters in length and can weigh up to 70 kilos (Wassilieff and O'Shea, 2006). The octopus are remarkable creatures, renowned for their intelligence, ability to problem solve, to in chameleon-like fashion transform their colour, to move at lightning pace through jet propulsion, learn backwards and memorise tasks, adapt and use tools, regenerate their appendages or arms and evade predators by squeezing into the smallest of spaces. The Octopus has nine brains, eight tentacled arms and three hearts. The centralised brain in the head of the octopus acts as a central processor, able to control each of its eight arms, whilst each arm contains a separate brain which can 'think' and act independently.

Amalgamating both traditional and contemporary knowledge to inform a conceptual model based on Te Wheke works to create a culturally aligned robust, practical yet flexible framework to facilitate transdisciplinary AI. The identification and naming of both the appendages or tentacled arms as kawekawe and the head as the ūpoko, makes immediate sense both in te reo Māori and within AI processes. Kawe in Māori means to carry or transmit. When one doubles a word in te reo Māori it acts to emphasise or extend the word's meaning. Therefore, kawekawe speaks to the dual ability of the octopuses' arms to reach out, touch, feel and grasp, pick up and carry objects (physically) or transmit information (sensory) to the ūpoko. Ūpoko in Māori means head, both physically and metaphorically. Therefore, a chief can be an ūpoko, making decisions, guiding, and leading others. Ūpoko can also be used metaphorically to describe the main, central, or head kaupapa (topic) of a discussion.

Applying the Te Wheke Model in transdisciplinary AI

Within the model various strands of expertise are represented by ngā kawekawe and the ūpoko represents the site of whakahononga (integration) - analysis, synthesis, implementation, and dispersal. The relationship between the kawekawe and ūpoko underpins a Māori-centric transdisciplinary

approach – allowing for peer-to-peer horizontal sharing of knowledge and the reciprocal flow of knowledge and perspectives, back and forth, within ako and wānanga practices.

Figure 6: *Te Wheke Model for Transdisciplinary AI*

Note: This is a reproduction of Figure 4 from page 13 to assist the reader. For a fuller description of the model, and permissions, please refer to the model on page 13 of this thesis.

The integration of both Western and Indigenous perspectives amalgamated within Te Wheke inform and demonstrate how transdisciplinary approaches in AI can achieve safer, culturally aligned and progressive AI models for use with ITM language communities. The amazing capabilities of Te Wheke are akin to the amazing capabilities of AI in its ability to transform assistive technologies for language learning, to adapt outputs or respond to different learning styles and levels, integrate with other technologies and tools to create more inclusive and immersive learning contexts and learn and incorporate nuanced cultural and sociolinguistic information.

In time, other aspects and characteristics of the wheke could be identified, defined and interpreted for incorporation into the Te Wheke model for Transdisciplinary AI. For example, the three hearts of a wheke could represent three central te ao Māori principles, tika (right), pono (truth) and aroha (love or care). These principles could inform the development of guardrails for ethical policy, standards and practice in transdisciplinary AI approaches for Māori contexts.

Conclusion

Transdisciplinary AI lends to the goal of creating increasingly safer, intelligent, culturally and socially relevant models that meet the needs of Indigenous end users. Diversity also helps to mitigate bias which improves diffusion and deployment amongst ITM communities. Where there are gaps in expertise, building diverse teams can be achieved through scholarships, cadetships or mentoring programs and actively seeking representation from diverse contributors, end users or stakeholders (Boch & Kriebitz, 2023). Indigenous language and cultural expertise across a range of disciplines, including language revitalisation, early education, socio and neuro linguistics, data sovereignty and understandings of child development must be central within AI projects that are developing AI for use within ITM language communities.

Māori education experts bring knowledge of distinctly Māori pedagogical concepts and approaches such as tuakana-teina, ako and wānanga that support reciprocal and horizontal learning within a transdisciplinary approach. Māori sociolinguists, bring a deep knowledge around the social environments in which te reo Māori language operates, taking account of the nuances within orality, dialects, translanguaging and whānau reo contexts. Understanding both traditional Māori and Western perspectives of the role of rhythm within infant neural, cognitive and language development, helps to facilitate and inform a more robust, holistic understanding of the key mechanisms involved in language uptake in utero and in the formative years. Within the context of this project transdisciplinary approaches are synergistic with the Tienga, Te Kawau Māro and Te Wheke models. A transdisciplinary AI approach integrates and values all contributions equally. Each discipline is indispensable in informing affordances in the design of AI assistive language tools to optimise their application within early native language acquisition contexts. Ongoing development and testing of Te Wheke as a model to achieve transdisciplinary approaches within AI for Māori and other ITM language communities, is an important future research goal.

Chapter 7: Conclusion

"… language is the lifeline and sustenance of a culture" (Pere, 1997, p. 9, as cited in McClutchie Mita, 2021). Almost half of the 6,000 known languages of the world are endangered. The process of ongoing loss or demise is neither inevitable nor irreversible (UNESCO, 2011). In post-colonial Aotearoa, te reo Māori struggles to survive due to its ongoing subjugation and the unfettered and overwhelming imposition of English as the dominant language. Barriers to accessing te reo Māori language learning resources are multiple and complex for whānau Māori, including their ability to access or provide quality immersive language environments for their tamariki at home. Over 80% of tamariki Māori are unable to access Māori medium early education, limiting their access to the critical rhythms that facilitate language acquisition.

Sustained investment and effort by Māori leaders and communities from the 1970s, and more recently government, are beginning to pay off with a marked increase in the number of people identifying as te reo Māori speakers. Te reo Māori remains vulnerable however and recent changes in government policy have seen a shift away from prioritising Māori language revitalisation. Now, more than ever, innovative and sustainable solutions are needed to aid RLS and the 'taken for granted' intergenerational transmission of the language to pēpi and tamariki, yet options to expedite language recovery in the home remain scarce.

The modern world increasingly relies on technologically driven communication solutions within social media, mobile apps and online platforms (Galla, 2018). Languages that remain digitally disadvantaged are likely to be at increased risk of obsolescence. The ability for te reo Māori to be accessed online improves its accessibility, useability and visibility. Digital functionality and presence especially within AI ensures te reo Māori remains relevant and attractive to future potential learners and speakers of the language. Ability to speak one's language and connection to culture greatly impacts stable identity development (Timutimu et al., 2009; Wilson & Kamanā, 2011). Raising the profile and status of the language can have flow on effects, increasing self-esteem and cultural pride for tamariki and rangatahi (Galla, 2018; Soria, 2016).

Improved integration of multiple knowledge streams in AI can create affordances in AI design that align to the technological needs of the user. In the case of designing AI to support early acquisition of the Māori language, (within whānau and within the home), requires the integration of diverse epistemologies and knowledge streams to come together. The critical insights from both Western and traditional Māori knowledge systems are integral to designing AI that optimises te reo Māori acquisition in pēpi Māori from in utero.

Increased integration of Māori language and culture in the digital space, should not be at the expense of its cultural integrity; nor should it result in the infringement of Indigenous rights. Ethical development of AI would see ITM communities leading AI development in the design of their own AI tools and solutions (Ovide & García-Peñalvo, 2016). Maintaining tino rangatiratanga, data sovereignty and security are important goals in AI for Māori end user communities and critical considerations for AI developers (Taiuru, 2024b). AI models trained on biased data or errant data sets, embed human biases, replicate and proliferate errors that can result in negative outcomes – perpetuating negative stereotypes, racism and bigotry and other undesirable affects. These unresolved safety and ethical questions must be dealt with effectively for AI to be safe for use within vulnerable, marginalised communities. Ahmad et al., (2023) recommends ongoing research in these critical areas to address the risk of bias, toxicity, improved data sovereignty and security. Transdisciplinary AI has the potential to create the context in which various streams of knowledge can be integrated holistically. This approach offers much in the way of a solution to the inherent complexities of designing AI with and for ITM language communities.

The direction, scope and future of AI development lies in the extent to which limitations and unresolved challenges of AI diffusion and application can be tackled and overcome. This extends to how they are deployed and applied in everyday situations and life contexts, including within the sphere of te reo Māori language transmission in the home. The benefit of integrating diverse knowledge streams within transdisciplinary AI development lends to the goal of creating increasingly safer, immersive and culturally aligned models. To successfully achieve transdisciplinary approaches in AI, developers must come together with te reo Māori language experts, cultural authorities and language communities to understand the unique needs of each Māori language community. Te Wheke, as a Māori conceptual model for transdisciplinary AI, holds real promise as a culturally aligned framework to support equitable, efficient knowledge integration. Further research, development and testing of the Te Wheke model would be valuable within future Māori AI projects. If AI is to aid the natural transfer of te reo Māori in the home to infants, it *must* be able to draw on a holistic understanding of the multi and complex factors that underpin early te reo Māori language acquisition and development.

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Glossary

Ako: teaching and learning

Aotearoa: New Zealand

Awa: river/s

Awhi: embrace

Haka: dance

Hapori: community

Hapū: sub-tribe

Harirū: shake hands

Hikoi: walk or march

Hongi: pressing noses in greeting

Iwi – tribe

Kaea: leader (usually in haka or waiata)

Kaiako: teacher

Kaitiaki: guardian or steward

Kaitiakitanga: guardianship or stewardship

Kaiwhiriwhiri Matua: head judge

Kapa haka (dance group)

Ka Piki: Māori language app focused on vocabulary building

Karakia: ritual incantation

Karanga: ceremonial call

Kaumātua: elders/grandparents

Kaupapa: topic or theme

Kaupapa Māori: Māori approach, philosophy, or methodology

Kawe: Carry or transmit

Kiingitanga: King movement

Koha: gift/gifting

Kōpū: uterus

Kōrero: talk

Kōrerorero: Māori language app for conversational practice

Kotahitanga: unity

Kowhaiwhai: painted rafters

Kumara: sweet potato

Kupu: word/s

Kura huna: hidden gifts of ancient wisdom and knowledge

Kura Kaupapa Māori: Māori medium primary and secondary school

Kura Wānanga: Māori tertiary education institution

Mahi: work

Mahi ā-ringa: hand gestures that accompany waiata

Mana – Prestige, authority, or spiritual power

Manaakitanga: care for others

Māori – Indigenous people of Aotearoa

Marae: traditional Māori meeting place

Mātauranga Māori: Māori knowledge, education, wisdom

Mātua: parents

Maunga: mountain/s

Mauri: essential life force

Mirimiri: rub or massage

Mita: dialect/s.

Mōteatea: traditional laments or chants.

Nau mai, hoki mai: welcome back

Ngā kawekawe: tentacles

Ngā kete o te wānanga: the three baskets of knowledge

Ngā Tamatoa: a Māori activist group formed in the 1970s

Ngāti Maniapoto: Southern Waikato-based iwi

Noa: ordinary or unrestricted

Oriori – chant composed and sung to children

Pākehā – A person of European descent/early colonial settler

Pakipaki: clapping

Paki: anecdotes or stories

Pakiwaitara: stories or narratives

Pēpi – babies or infants

Petihana Reo Māori – Māori Language Petition

Poi: swinging ball on string

Poipoi – to nurture or care for, often used in the context of child-rearing

Pōpō – Patting or rhythmic motion and title of a famous oriori

Pou reo: highly proficient language speakers

Poutama: steps

Pou whakairo: carved posts or figures

Pouwhenua: boundary marker

Pūkana: widening eyes

Puna: pool

Pūrākau: origin stories

Rākau papatūpuna: notched sticks used in the recitation of whakapapa

Rangatahi: young people

Rangatiratanga: chieftainship or authority

Raranga: weaving

Rohe: area

Tā: Sir

Taha-Māori – Māori-centric or Māori side

Taiao: Natural environment

Takahi: stamping

Tākaro: play

Tamariki: Children

Tamariki Māori: Māori children

Tāmoko: traditional tattoo

Tāne-nui-a-Rangi: deity in Māori theology

Taonga: treasure

Tapu: sacred or restricted

Taputapuātea: A sacred place and significant marae in Polynesia

Tara: wall/s

Tātau: Māori language app focused on numbers and counting

Tauira: student

Te ao Māori – The Māori world

Te ao mārama – The world of light

Te ao wairua: spiritual realm

Te ara mōwai – The birth canal

Te Aute – A Māori boarding school

Te Kapehū Whetū: a 300-point Star Compass

Te Kōhanga Reo: Māori language preschool

Te Kore: void

Te Maihi Karauna: The Crown Māori Language Strategy

Te Maihi Māori: The Māori-led Language Strategy

Te Matatini: the many faces

Te Moana-nui-a-Kiwa: the Pacific Ocean

Te Paipera Tapu: the Bible translated into Māori

Te Pō: night or darkness

Te Puni Kōkiri: The Ministry of Māori Development

Te reo ā-karu: communicating with eyes

Te reo ā-tinana: body language

Te reo ā-whio: communicating with whistling

Te reo Māori: the Māori language

Te Taura Whiri I te Reo Māori – The Māori Language Commission

Te tihi o ngā rangi: the top layer of the heavens

Te Tiriti o Waitangi: Treaty of Waitangi

Te wairua o te kupu: the spirit of the language

Te whaiao: space between Te Pō and Te Ao Marama, also used to describe the birth canal

Te whare tangata: womb

Te Wheke: the octopus

Te Wiki o Te Reo Māori: Māori language week

Tikanga Māori: correct Māori practice or custom

Tino rangatiratanga – Self-determination or sovereignty

Tohunga: specialists or expert knowledge holders

Tohu whenua: natural landmarks

Tuakana-teina: older and younger (respectively) siblings, cousins, peers of the same gender

Tūāpapa: foundation

Tukutuku: woven panels

Tūpuna: ancestors

Tūpuna Māori: Māori ancestors

Ūpoko: head

Wāhine Māori: Māori women

Wāhi tapu: sacred sites

Wai: water or who/whom

Waiata: Song or chant

Waiata-ā-ringa: songs with hand actions

Waka: boat or vessel

Wānanga: approach to, or place of learning

Whakahononga: Integration

Whakapapa: genealogy

Whai muri mai: coming up afterwards

Whanaungatanga: relationships and connections

Whakahononga: Integration

Whakamā: shame or embarrassment

Whakapapa: genealogy

Whakarongo: listen

Whakataukī: proverb

Whānau: Family or extended family

Whanaungatanga: relationship/s

Whare: house

Wharekura: Māori tertiary education institutions

Wharenui: ancestral house

Whare wānanga: house/place of higher learning

Whāriki: woven mats

Whētero: protruding tongue

Wiri: quivering hands

Glossary (non-Māori words)

Fa'ataupati: Samoan slap dance

Fauna: Animals

Flora: Plants

Lingua franca: A common language used for communication between speakers of different languages

Acronyms

AI: Artificial intelligence

API: application programming interface

CMS: Church Missionary Society

DL: Deep Learning

EEG: Electroencephalography

EU: European Union

FL: Federated Learning

HyFDCA: Hybrid Federated Dual Coordinate Ascent

ID-Sov: Indigenous Data Sovereignty

INS: Interpersonal Neural Synchrony

IP: Intellectual property

ITM: Indigenous, tribal and marginalised

LLMs: large language models

MA: Master Apprentice

ML: Machine Learning

RLS: Reversal of Language Shift

TMR: Te Mana Raraunga

UNDRIP: United Nations Declaration on the Rights of Indigenous Peoples

UNESCO: The United Nations Educational, Scientific and Cultural Organization