TE KŌHANGA O TE TŪĪ

The potential of voice recognition technology and artificial intelligence (AI) to support the acquisition of te reo Māori and digital literacy in early child development – A literature review

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TE IPUKAREA

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There are many people today and throughout history who have given tirelessly of their energy, skill, talent, and time to fight for the survival of the Māori language. They have fought to save the language not only for our benefit but for the benefit of future generations - ngā mokopuna[1]. We wish to acknowledge their valuable contributions, individual and collective, in laying the foundation upon which this work stands.

We also want to acknowledge Associate Professor, Dean Mahuta, for gifting us the name, Te Kōhanga o te Tūī – the nest of the tūī, for this kaupapa[2]. The tūī is a remarkable bird that could imitate other sounds within te taiao[3], especially the sounds of other birds - they could even be taught to speak the language. Exploring the potential of digital technology to support the acquisition of te reo Māori[4] in the early years of child development is an exciting prospect … even more so if it results in increased access to the Māori language for Māori children. Two primary points that Māori language revitalisation experts agree on, is that for te reo Māori to survive it *must* 1) be transmitted intergenerationally and 2) be heard and spoken across all domains, especially in the home (Higgins, 2015; Ka'ai et al., 2020).

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[1]   grandchildren
[2]   project, topic, issue, theme or subject
[3]   environment
[4]   the Māori language

Executive Summary

Recent evidence has shown strong links between language, culture, identity, academic success, and higher levels of reported wellbeing for Māori (Smith et al., 2019; Mhuru, 2020). Whilst the evidence suggests tamariki[5] who attend Māori medium education do better on average than their Māori peers in English-medium education, there is also evidence that exposure to language and culture in the home may confer additional benefits to tamariki Māori regardless of whether they participate in Māori medium education or not (Ministry of Education, 2020).

Building the foundations for these important links begins in the early years (first 1000 days of life) when a baby's brain development is exponential (Centre on the Developing Child, 2022). Newborn babies begin laying the neural pathways for language in utero and continue to shape the neural circuitry for language development through a process called perceptual narrowing or pruning. Linguistic anthropologists, Schieffelin and Ochs, (1986) addressed the issue of socialisation through language and found that enculturation[6] and language acquisition occur simultaneously. These findings have been further supported by the recent work of Perszyk and Waxman (2019) who found that babies as young as three months old were capable of linking language and core cognitive capacities.

Artificial Intelligence (AI) and voice recognition technologies have been proven to promote phonic awareness in young children (Grist, 2020; Furlong et al., 2021) and there is increasing evidence that child-adult interactions can be mediated with digital tools to support foundational language skills (Roseberry et al. 2014; D'Agostino et al., 2016). However, the use of digital technology with very young children engenders mixed responses and recommendations from child development experts and early educators to approach increased exposure of digital technology in early childhood with caution. Designing and prototyping a digital app that combines the computational power of AI with voice recognition technology, should therefore, require designers to consider a number of sociolinguistic, developmental, cultural and security factors.

The findings of this review underscores the importance of te reo Māori as an active language in the home for young Māori children, as having access to Māori language in the early years helps to lay the neural, cognitive, and social foundations for Māori identity and culture (Fishman, 1991). Links to language and culture are recognised factors in academic success for Māori (Ministry of Education, 2020).

Learner identity is enhanced when children's home languages and cultures are valued in educational settings and when Kaiako are responsive to their cultural ways of knowing and being. For Māori this means Kaiako need understandings of a world view that emphasises the child's whakapapa connection to Māori creation, across Te kore ('the nothingness'), te pō ('the night'), te ao mārama ('the world of light'), atua Māori ('Māori gods') and tīpuna ('ancestors'). (Ministry of Education, 2017: 12, cited in Rameka, 2018)

This review seeks to reconceptualise and inform how access to te reo Māori in the early years can be facilitated by combining voice recognition and AI technologies for use within the home. Finally, the review identifies multiple opportunities for future research.

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[5]   children
[6]   learning of sociocultural norms

Introduction and background

At the end of 2020, researchers from Te Ipukarea Research Institute met with local iwi[7] and community leaders to discuss the merits of a collaborative research project focusing on the early years of child development. One of the key drivers for collaboration was an aligned interest in improving outcomes for rangatahi Māori[8] by maximising opportunities in the home for te reo Māori language acquisiton and learning in the early years.

Following the first Covid lockdown period, between March and May 2020, Whai Maia, the social service arm of Ngāti Whātua Ōrākei, partnered with Koi Tū: The Centre for Informed Futures to investigate the negative impact from Covid-19 lockdowns on rangatahi education (Hunia et al., 2020). Ngāti Whātua whānau were surveyed with results showing young people were experiencing increased challenges to their academic achievement because of online distance learning. The findings of the study pointed to several contributing factors including, the ability for parents and whānau to provide adequate learning support to their children at home, low levels of digital literacy and fluency, and a lack of resilience to overcome the setbacks.

The importance of strengthening links to language, culture and identity and increasing digital literacy levels within whānau were highlighted as potential areas to leverage better outcomes for rangatahi. The report predicted inequities in the educational outcomes of rangatahi Māori were likely to persist and grow for at least 10 years post Covid-19 and that digital divides[9] would widen as a result. To successfully overcome these challenges, rangatahi Māori require increased connection to their language and culture, increased levels of digital literacy and fluency, resilience, self-efficacy, and the social-cognitive bandwidth to cope with the rapid digitisation of their future world. Laying the foundation for these capabilities and capacities begins in the early years of child development (Sroufe et al., 2010). Combining the computational power of AI with voice recognition technology has the potential to aid te reo Māori acquisition and learning in pre-school age children whilst simultaneously increasing their mediated healthy exposure to digital technology. This integrated literature review aims to explore that potential.

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[8]   young people or teenagers
[9]   The primary 'digital divide' is the gap between those who have access to digital devices, internet connectivity, and digital skills and those who do not. A second divide occurs where there are gaps between those that have access to complex and stimulating educational resources online and those who do not, even if they have access to devices

Māori conceptual frameworks and approaches

Decolonising frameworks

Transformative kaupapa Māori[10] theory is a decolonising praxis that seeks to indigenise spaces within Aotearoa, New Zealand by recentering and legitimising Māori ways of knowing and being, (Rangihuna et al., 2020). Kaupapa Māori theory has an emancipatory intent that can only be exacted by Māori from a te ao Māori[11] position, (Smith, 1999; Pihama, 2001; Wehipeihana, 2013). Challenging dominant social and theoretical discourse that results in the marginalisation of mātauranga Māori[12] is an important endeavour for researchers who identify as Māori. John Rangihau (1975) espoused the importance of tribal identification, locating oneself within the broader homogenised identity of Māoritanga or pan-tribal Māori identity.

> My being Māori is absolutely dependent on my history as a Tūhoe person as against
> being a Māori person. It seems to me that there is no such thing as Māoritanga
> because Māoritanga is an all-inclusive term which embraces all Māori
> (Rangihau, 1975, pp.189-90)

Rangihau's (1975) rejection of Māoritanga in this context, reflected a rise in the 1970s in Aotearoa of tribal consciousness generally and suspicion amongst Māori that the unifying of Māori identity was yet another instrument of colonisation and assimilation. However, not all Māori shared this sentiment. Urban Māori who lost their links to iwi and marae often rejected tribal fundamentalism, viewing it as divisive, legitimising Māori identity on the sole basis of being able to trace one's whakapapa or tribal heritage. The contemporaneous Māori identity has emerged as fluid and dynamic, both tribal and non-tribal. Māori nationalism, under the banner of Māoritanga[13] and rangatiratanga[14] has been pragmatic in asserting rights to sovereignty and self-governance, whereas promotion of unique tribal identity has been important to preserving heterogeneity and the rich diversity within Māori language and culture. Transformative Kaupapa Māori theory allows for this dynamic and fluid expression of Māori identity. Māori researchers are able to express themselves as Māori, defining themselves in relation to western socio-political thought and doctrine, from peripheral 'other' to central within the research paradigm. As Ka'ai-Mahuta (2010) stated:

> 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 world-view and therefore accommodates the world-view of
> the researcher in the research method (p. 16)

Theoretical constructs are after all hypothetical social constructs, based on a set of ideas or opinions about a particular subject from a particular viewpoint. Since the Age of Enlightenment, those viewpoints within academic research have been largely Euro and/or androcentric and frequently deficit by design. Māori, as with other indigenous peoples, had their own particular pre-colonial viewpoints, sets of ideas, hypotheses, theories and epistemological practices. The imposition of western theoretical constructs on Māori by non-Māori scholars and theorists have contributed to the marginalisation and subordination of Māori within academia (Pihama et al., 2015). The lack of research responsivity and failure to acknowledge, understand, recognise, and include Māori epistemological approaches and methodologies reflects, what some have referred to as, an elitism that *West knows best*, a position that has been increasingly and vehemently

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10   Māori principles
11   Māori world view
12   Māori knowledge and epistimologies
13   Māori cultural practices, Māori ways of knowing and being
14   self-determinatio, authority, sovereignty

challenged by leading Māori scholars (Ka'ai, 2012; Pihama et al., 2015; Smith, 1999; Janke, 1999; Macfarlane & Macfarlane, 2019).

Recentering Māori knowledge within the academy requires Māori researchers to engage with the process of developing Māori-centric theoretical constructs, methodologies, and Māori-centric discourse. Linda Smith (2020) talks about the inherent difficulties involved in decolonising disciplines to reach a state of intellectual parity and equilibrium within the academy and maintains that decolonising is like putting together a jigsaw puzzle - we have quite a few of the pieces that give us a rough idea, but many of the pieces are missing. Smith (2020) asserts, we need to recreate through replication as a way of coming to 're' know, to rebuild our own discipline that is mātauranga Māori[15] in order to fully understand ourselves and our ways of knowing.

Academic activism is then the preserve and choice of indigenous academics, to engage with this liberatory process, or not. As Māori indigenous academics and researchers, we welcome and embrace this prerogative by approaching this review with the emancipatory intent of recentering and legitimising mātauranga Māori and in doing so hope to replenish the puna mātauranga[16] of our tūpuna[17] now and in perpetuity.

This literature review engages a Kaupapa Māori Integrative approach to identify, review, critique and synthesise a diverse range of relevant and interrelated materials pertaining to our areas of interest. The review is undertaken by a research team that is predominantly Māori, with the first author and two members of the research team being of Māori heritage.

Māori metaphorical constructs

Te ao Māori[18] is a world rich in metaphor and simile. The natural world and all its phenomena have traditionally provided Māori with a veritable array of constructs with which to conceptualise, understand, know, and articulate a Māori-centric world view. Within this metaphoric world, people and their unique traits and characteristics are often personified, and ascribed kindred qualities found in nature – birds, trees, fish, sky, etc. The revitalisation of Māori language and culture necessitates the revitalisation of this uniquely Māori way of seeing and experiencing the world. It is only through this filter or lens that the complexities and mechanisms underpinning real world problems[19] facing Māori today can be fully conceived of, understood or addressed.

To that end, this review engages the metaphor of the pā harakeke or flax bush with its multiple rau or leaves as a logical and appropriate conceptual framework to guide an integrative review. The multifarious nature of the pā harakeke allows for the identification, integration, and dynamic exploration of a variety of artefacts within a defined but divergent range of research materials. Because the focus of this literature review relates to the acquisition of the Māori language within whānau[20] settings, the term, te reo o te pā harakeke[21], has been adopted from an earlier study (see: Ka'ai et al., 2020) to describe a child's access to their native language within the home.

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[15] Māori knowledge
[16] wellspring of Māori indigenous knowledge
[17] ancestors
[18] the Māori world
[19] Real world problems are probelms existing or occurring in reality – drawn from or drawing on actual events or situations. Merriam-Webster Dictionary, accessed, 5/01/2022. https://www.merriam-webster.com/
[20] family
[21] language of the flax bush

Pā Harakeke conceptual framework

A common metaphorical use of the pā harakeke within te ao Māori is the conceptualisation and articulation of social relationships within extended family or societal groupings, i.e., whānau, hapū[22] and iwi. Within this metaphorical construct, the rito, central shoot or leaf of the flax bush, typically represents a child's place as central within their whānau and community. The value and importance of the rito is paramount to the life of the pā harakeke as all future growth emanates from it. On either side of the rito are the mātua, awhi rito[23] which typically represent parents, grandparents, wider whānau and society. The awhi rito provide necessary protection and support to aid the healthy growth and `development of the rito. The current review adheres to this customary understanding of the symbiotic relationship between the rau and rito within the pā harakeke, however, reconceptualises the central space or rito to include Māori children and their native language. Implicit in this expression of the model is the notion that the wellbeing of pēpi Māori[24], their identity, language and culture are inextricably bound. Māori children require strong links to language, culture, and identity to thrive as Māori, whilst the survival of the Māori language is contingent upon it being valued and spoken by future generations.

The Pā Harakeke conceptual framework consists of one rito, representing tamariki Māori and their language at the centre *and* four rau, representing four independent but interrelated foci:

- Te reo Māori language loss and revitalisation
- Child/infant language and brain development
- Digital literacy development in the early years
- The potential of voice recognition technology and AI in te reo Māori acquisition and learning within the home

Pā Harakeke methodology

Criteria and selection

Artifacts relating to the rau and rito as our interrelated areas of interest included but were not limited to, grey literature, research papers, presentation notes, website publications, podcasts, books, reviews, lectures, journal articles and news media. The criteria for inclusion of any artifact were its authentication, through the authors' direct engagement with the source, evidence of peer review and / or citation and relevance to the foci of interest. Materials relating to Māori language loss and revitalisation were not limited by date as various quality source materials were published as early as 1967. Any artifact published prior to 1990 relating to early brain and language development, digital literacy and literacy, AI or voice recognition technology in language learning were excluded on the basis that since the early 1990s significant advances (through a plethora of scientific studies) have built on and added to our comprehensive understanding in these areas. A total of 768 artifacts were reviewed or skimmed for relevance with 101 meeting the criteria for inclusion.

The following string or combination of key words were adopted to source relevant materials:

- te reo Māori AND acquisition/learning / loss;
- early brain development AND language / neural synchrony / rhythmic entrainment / hyper scanning;
- AI AND digital language learning / deep learning/machine learning / children;

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[22] sub-tribe
[23] guard stems, protector of the rito
[24] Māori infant/s

- voice recognition technology AND language acquisition / learning / children; screentime AND
- early development/child development/; digital literacy AND early exposure/benefits/drawbacks.

The key words and strings were used to scan across several online search engines such as JSTOR; MAI; WPI; Google Scholar; SAGE; Wellesley; JMIR; Frontiers; PubMed. Snowballing techniques, skimming and thematic analysis were used to identify the materials within the scope and against the criteria. Zotero was used to store and organise materials and citations across the range of foci and themes.

In line with the Pā Harakeke framework and goal of the integrative review, each rau was examined separately within the body of the review, although some areas of interest overlapped or intersected and as such could not be treated as distinct and separate. As much as possible, the exploration of the relationship between the rau and their influence on, or relationship to the rito, was handled within 'Whiriwhiria'[25] the integration, discussion, and findings section.

Definitions and clarifications
- Where Māori words are used in the body of the text for the first time within this review a translation is footnoted. A Glossary can also be found on page 31.
- Where there is need to elaborate on the meaning of a particular Māori word, phrase, concept, or where a broader explanation of a term in English or Māori is required, the elaboration has been footnoted.
- Literacy or literacies – the practice linked to information identification, retrieval, and evaluation of traditional (paper-based), plural or multi-literary sources including digital media, often characterised by mobility, connectivity, multimodality, and multiple media.
- AI – Artificial intelligence, deep or machine learning.
- voice recognition –voice recognition technology or software.

Exclusions
- Any previous review or research study related to the use of AI or voice recognition technology where there is a potential conflict of interest with the focus of the current review, especially where there are ongoing investigations into the use of these technologies with indigenous peoples elsewhere (Daly, 2019).
- Any artefact/s prior to 1990 relating to AI or voice recognition technology, digital literacy and fluency, child language and brain development on the basis that more recent research has provided significant new insights relating to these areas of study.

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[25] to weave or discuss

Te Rito: Language, culture, and identity

Mā wai te reo e kawe ki ōna whenua haumako,
Mā wai ia e marotiritiri kia pītau mata-ā-tipu,
kia anga nui ki te rā, kia kawea ia e ngā hau kāinga, e ngā hau takiwā ki a
Pokotaringa,
ki a Ngākau-nui, ki a Whakaihi mā?

Who will carry the Māori language to its fertile lands,
and protect and nurture it
so that it may unfurl towards the sun, to then be carried on the home breeze
and be heard in the homes and across the land by those who are passionate and
dedicated? (Milroy, 2014)

Language and learning

Language is foundational to human development and a baby's brain is naturally wired to learn language. At birth, newborns can discriminate broadly among human languages based on durational variability and rhythmic class (Nazzi et al., 2000; Kuhl et al., 2006; Bosch & Sebastián-Gallés, 1997; Zacharaki & Sebastian-Galles, 2021; Gasparini et al., 2021; May et al., 2011). In fact, a neonate can perceive the speech sounds of the entire world's languages - approximately 600 consonants and 200 vowel sounds (Mampe et al., 2009). However, there is strong and growing evidence that from as early as 3 months of age, infants begin to decrease their ability to discriminate or tell apart non-native consonant and vowel sounds that are not used contrastively or often in their native language (Best & McRoberts, 2003; Krasotkina et al., 2018). This phenomenon is commonly called 'pruning' or perceptual narrowing whereby the neural connections associated with non-native languages are discarded or 'pruned' away. This process of declining discrimination peaks at around 9-12 months of age (Polka & Werker, 1994). Reduction of the early neural capacity to master the morphosyntax[26] of a language has implications for second-language learners later in life (Ventureyra et al., 2004; Au et al., 2008). These implications will be further explored in Rau 2: Brain and language development.

The cries of a newborn broadly mirror the prosodic contours of their native language (Mampe et al., 2009). By 2–3 months of age, infants increasingly 'tune in' to the sounds of the language/s of their environment and as stated above, the pruning process ensues. There is increasing neural and behavioural evidence that rhythm and prosody are instrumental in an infant's ability to 'tune in' or neuronally entrain[27] to the sounds of their own native tongue and dialect. Moreover, evidence suggests that infants' native language becomes a perceptual magnet shaping infants' perception of the sounds of native and non-native languages (Perszyk & Waxman, 2019).

The rhythmic class of Māori is Mora-timed (measured on the acoustic qualities, periodicity[28], stress-timing, intonation, and durational variability in speech rhythm) and is closest in rhythmic class to that of some Asian and other Pacific languages, such as Taiwanese, Cantonese, Japanese and Hawaiian (Maclagan et al., 2009). English is syllable-timed and closest in rhythmic class to Germanic languages, i.e., Dutch, German, Russian. There is substantial evidence linking the early migratory patterns of Māori to the wider Asia-pacific region or early Austronesia and it is therefore unsurprising to find associations or relational links through whakapapa[29] between native Māori and other languages of the Asia-pacific region (Sneddon, 2003).

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[26] moprphology and syntax relates to the formation rules of language
[27] alignment of ongoing neuronal activity to the temporal structure of external rhythmic input streams
[28] perodicity refers to events and speech constituents that reoccur periodically in speech
[29] genealogy, ancestryn

Ordin and Polyanskaya (2015) suggest that an infant's ability to recognise the nuances or rhythms in speech is of the utmost importance for their language acquisition and speech processing (e.g., for development and implementation of language-specific segmentation strategies). For Māori newborns, this means being exposed early to language speaking environments that include the rhythms of te reo Māori to help shape their sociolinguistic development *as Māori*.

Culture and Identity

The study of sociolinguistics places language at the centre of identity development, important to cultural norms and beliefs and to the intergenerational transmission of culture (Fishman, 1991). Retaining and developing the neural foundations for language is a primordial underpinning to the enculturation of a child who is ethnically Māori. There is increasing evidence that links to language, culture and identity positively impact academic achievement for tamariki Māori. Education-sector research in Aotearoa has identified several factors associated with improved educational outcomes for Māori students (Ministry of Education, 2020):

1. *For Māori students, positive cultural identity and connection to Māori culture and language, have large positive effects on NCEA outcomes.*
2. *Māori students from households that place a strong emphasis on cultural identity, connection and language have the highest rates of reported whānau wellbeing and higher NCEA achievement than peers from households with weaker cultural identity and connectedness.*
3. *Māori-medium education is effective – Māori students attending Māori-medium schools generally have substantially higher attainment than their peers in English-medium education.*
4. *Kaiako Māori have a very positive effect on Māori students' educational outcomes. In mainstream schools with no Māori-medium offerings, but with high numbers of Māori amongst teaching staff, Māori students achieve NCEA at comparable rates to their peers in Māori-medium education (Adapted from Ministry of Education, 2020, p.1).*

There is also evidence that rangatahi Māori gain higher achievement and remain at school longer if they have access to Māori-medium education, whether through kōhanga reo[30], or kura kaupapa[31]. This growing body of evidence, that strong links to language and culture has clear and proven benefits for Māori children emphasises the importance of the early establishment of these links. Unfortunately, there can be numerous barriers to tamariki Māori accessing their native language early, including the limited number of adult speakers or limitations of non-fluent adult speakers (parents, whānau or teachers) as effective language models. Further, the efforts of whānau Māori to access Māori-medium early education options are hampered by competition for placements due to high demand and limited numbers of local, quality providers (Ka'ai, 2021).

As previously stated, the best time to learn language is in the early years of child development when brain growth and plasticity is at its optimum and the home environment is the first language environment, where infants begin to neuronally entrain and attune to language. But for the home to be truly viable as a space for te reo Māori language acquisition the Māori language must be heard and spoken regularly enough and to a level of proficiency that supports language learning. Reversing language shift through everyday use of te reo Māori language at home is essential for Māori language revitalisation (Hinton, 2013).

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[30] Māori language preschool
[31] primary school operating under Māori custom and using Māori as the medium of instruction

Home Language

Kō te reo te mauri o te mana Māori
The language is the life force of the mana Māori (Tas cited in Waitangi Tribunal,
1985, p.34)

Fishman (2001) also argues the reinstatement of the language in the home is critical to its future survival (cited in Ka'ai et al., 2020). Ratima and May (2011) affirm Fishman's (2001) statement, maintaining that learning language is a holistic endeavour and must be undertaken within its social and cultural contexts.

A parent's role is vital in shaping their children's attitudes toward their home language with their own attitudes and beliefs being fundamental in a child's sense of identity, self-esteem, and cultural pride (Chrisp, 2005; Ka'ai et al., 2020). For language revitalisation to be successful the role of parents to facilitate access to te reo Māori for the purposes of intergenerational transmission is vital, however, this can be particularly daunting and onerous for parents with limited language proficiency. There is an urgent need to develop effective resources and tools that support parents to increase their levels of fluency, confidence, and engagement in te reo Māori with their tamariki.

Rau 1: Te Reo Māori loss and revitalisation

The loss of the Māori language has had a profound impact on the health, wellbeing, economic and social positioning of Māori in Aotearoa. The late Whatarangi Winiata's statement in Luke (2021) on the importance of the Māori language to Māori should be nothing short of catalytic to the conscience of all New Zealanders to engage in the struggle for the future survival of the language as a requirement of citizenship and civic responsibility:

> *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. (p. 183)*

The survival of Māori as a people is contingent upon the survival of the Māori language as the *carrier* of Māori culture. The fundamental role of language as a carrier of culture was rightly 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)*

Language loss

Prior to the signing of Te Tiriti o Waitangi[32] in 1840 the dominant language of Aotearoa was te reo Māori. Early Pākehā or European settlers were required to speak the language to communicate and trade with the local, native population. However, once the Pākehā population gained parity with Māori in approximately 1860, a gradual shift in language dominance occurred (Ministry for Culture and Heritage, 2021). Up until the end of the second world war, most Māori were first language speakers of their native tongue despite concerted efforts by the colonial administration to irradicate it. Those efforts included the introduction of the Native Schools Act in 1867 which determined that all school children should receive instruction in the English language only (Ministry for Culture and Heritage, 2021). This policy was tied to both 1) a genuine albeit misguided belief that the assimilation of Māori into English society was in the best interests of Māori and 2) to the statewide funding of education by way of annual meritorious grant or subsidy. These were strong motivators for change and sadly resulted in many schools implementing this policy with ruthless efficiency – physically punishing Māori students for speaking their native tongue at school (Ministry for Culture and Heritage, 2021). Despite the moratorium on speaking Māori within educational settings, te reo Māori continued to be largely the language of the home up until the latter half of the 1940s.

Rapid decline of the language in the home accompanied the urban drift of Māori from their rural homelands following the second world-war (Meredith, 2000). The influx of Māori to urban centers garnered policy responses, such as 'Pepper Potting', the policy of strategic social integration, whereby Māori whānau were located within all Pākehā communities. These policies were designed to expedite assimilation of Māori to the 'Kiwi' way of life. The effect of these policies had a devastating impact on the Māori language and by 1980 less than 5% of the population within Aotearoa could speak the language conversationally and fewer than 20% of Māori were regarded as native speakers (Ministry for Culture and Heritage, 2021). Benton (1984) predicted that if the rate of loss of the Māori language continued it would become largely ceremonial,

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[32] The Treaty of Waitangi

reserved only for formal occasions, communication on marae and within the preserve of a few dedicated whānau.

Reclamation

To stave off complete annihilation, passionate protagonists took decisive action. From the 1960s, activist groups, such as the Auckland-based Ngā Tamatoa[33], Victoria University's Te Reo Māori Society, and Te Huinga Rangatahi[34] were instrumental in implementing te rā me te wiki o te reo Māori[35] marking the beginning of the modern revivalist movement (McCaffery, 2015). The first kōhanga reo was established at Pukeatua, Wellington in 1982 with approximately 80 kōhanga reo established by 1984. In 1985 the Waitangi Tribunal heard the Te Reo Māori claim, finding te reo Māori was a taonga or treasure and under Article Two of Te Tiriti the Crown was obligated to actively protect it (Ministry for Culture and Heritage, 2021). This made way for the Māori Language Act, 1987 which established Te Taura Whiri i Te Reo Māori[36] and the recognition of te reo Māori as an official language alongside English (Rei & Hammon, 1993). Unfortunately, these changes did not automatically result in a shift of consciousness or increased effort by the Crown to actively protect te reo Māori. No more so was the lack of valuing of the Māori language more evident than within mainstream media; deregulation of media industries took place in the mid-1980s, but Māori content remained minimal (Smith & Abel, 2008).

Māori broadcasting rights went hand-in-hand with the fight to save the language and leaders within Māori media and language revitalisation continued to agitate for recognition of the rights of Māori to share the airwaves. Those efforts finally paid off in 2004 with the establishment of the first dedicated Māori programming channel, Māori Television. Initial reactions were mixed with the channel garnering an audience of 300,000 in its first month of operation, however, by its fifth-year on-air the station was attracting a viewership of approximately 1.5 million per month, constituting half of all Māori and over a third of the total New Zealand population (Throng, 2009). Current attitudes to Māori broadcasting represent a shift in attitudes generally toward the value of the Māori language with most, 84% of all New Zealanders, stating they believe Māori television should be a permanent feature within the New Zealand broadcasting landscape (McCaffery, 2015).

The current picture

The efforts to reestablish the status of the Māori language and turn the tide of extinction have thankfully proven successful in slowing the rate of language loss. There have been many positive developments since the Māori Language Act was enacted in 1987, including the establishment of:

- *Over 400 Kōhanga Reo*
- *72 Kura Kaupapa Māori or Whare Kura*
- *Te Taura Whiri I te reo Māori (Māori Language Commission) who's primary aim is to promote te reo as a living language*
- *29 Māori radio stations*
- *two 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*

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[33] The Young Warriors
[34] New Zealand Māori Students' Association
[35] Māori language day and week
[36] The Māori Language Commission

There are promising indicators that the Māori language has turned a corner and emerging evidence of positive language shift (Te Kupenga, 2020), however revivalists are cautious in making overly inflated predictions, claiming language revitalisation is a three-generation process and consistent long-term strategies are needed (Higgins, 2017). With only one in six Māori within Aotearoa currently able to speak the Māori language to a high degree of fluency (Te Kupenga, 2020), there is still a long way to go to secure the language's future survival (Higgins, 2015).

The future of te reo Māori

Te Maihi Karauna (Crown Māori Language Policy) 2019-2023, sets out the revitalisation priorities for the Crown to focus on for the next five years and identifies three key elements that are critical to reversing language shift (Te Puni Kōkiri, 2019):

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

Reversing language shift requires the hearts and minds of all people in Aotearoa to shift. For Māori children to grow strong in their identity and culture they must feel proud to be Māori. The historic undervaluing of the Māori language and culture has resulted in language trauma for Māori, often accompanied by a deep internalised sense of whakamā[37]. The evidence of language links to early cognition and positive identity development indicate that early language learning and enculturation is foundational to healthy identity development. For Māori children to grow and internalise a sense of pride in their language and culture the language needs to be ubiquitous. Moreover, adult's worldviews are largely influenced by their cultural background and can have a powerful influence on their ability to successfully adapt to the wider environment. International literature suggests that positive ethnic identity can play a protective role in minority learners' lives (Bowman & Howard, 1985; Miller & Kaiser, 2001; Oyserman et al., 2007).

Complimentary strategies are required that support collaborative action and multimodal revitalisation methods. There is not one *best* way to restore the Māori language, nor an 'either/or' approach. What is needed is an 'and/and' approach where everyone's contribution is welcomed and valued (Higgins, 2017). As aforementioned, the importance of increasing the use of te reo Māori within the home environment cannot be understated. By far, the strongest predictor of language revitalisation and maintenance of a language is the level of language spoken in the home (Ka'ai et al., 2020).

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[37] shame

Rau 2: Brain and language development

Interactive engagement

'Serve and return' or interactive engagement between adults and infants in the first 1000 days helps to build the neural foundations that support sturdy brain architecture (Centre on the Developing Child, 2022). These neural connections are found across multiple regions of the brain, and are the building blocks for language, learning, social-emotional development, executive functioning, and self-regulation. They are also important to the skills that help children and adults focus, plan, prioritise, remember important information and control impulses. Because serve and return is responsive to children's needs and interests, it also buffers them from the effects of serious stress, which is crucial for building resilience. However, the underlying neural mechanisms associated with learning and social engagement in young children are still largely unknown, (Piazza et al., 2020). Many of the studies conducted on face-to-face social interactions have occurred in controlled settings and are limited in their exploration of the underlying neural mechanisms of joint behavior as it naturally unfolds within natural settings (Dumas, 2011).

Recent advances in neural imaging techniques called hyper scanning[38], are providing neurologists with new tools to explore brain activity between two or more subjects, informing how interactive engagement occurs in real time within natural social contexts. Importantly these studies are providing new insights into the role adult, child interactions play in infant brain and language development and in infant social learning (Piazza et al., 2020). Interpersonal neural synchrony (INS) involves groups of neurons called neural oscillators, that are important in supporting mutual or synchronised brain activity between two or more people (Lakatos et al., 2019; Hoehl et al., 2021). Building on the work of Ruth Feldman (2007), focused studies on the enablers to neural synchrony have been conducted by leading researchers globally (Nguyen et al., 2020). Emerging evidence affirms that reciprocity through cooperation and play are mechanisms that increase neural synchrony between infants and caregivers. Joint or shared attention is also an important mechanism to facilitate synchrony, allowing infants to leverage the skills and knowledge of an adult and lead the focus of the interaction through more complex forms of social communication, i.e., eye movement and gesture. Other factors, such as affective touch, mutual gaze, rhythmic movement, singing, and speech are also influential (Markova et al., 2019).

Early language links to cognition

Children are not passive actors in their development. Child agency or child-led interactions support closer connectivity, influence parental responsiveness, and increase positive parental attitudes and behaviours (Nguyen et al., 2020). Perszyk & Waxman (2019) studied the links between infant speech perception and early cognition and found that infants listening to a language of a similar rhythmic class (German) to their own native tongue (English) formed object categories, whereas infants listening to a language that differed considerably in rhythmic and prosodic properties from their native tongue (i.e., Cantonese) failed to build object categories. This is the first evidence that infants as young as 3 months of age can specify, through the processes of neural entrainment, perceptual narrowing or pruning and INS, which language/s they will link to core conceptual and cognitive capacities. This finding has implications for not only language development but for how we understand infant thought development and perception. As an infant increasingly tunes into the rhythms of their native language, they devote greater attentional resources to it, reducing their ability to tune in to non-native sounds. This in turn has implications for language acquisition because infants who show

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[38] typically combining functional magnetic resonance imaging (fMRI), electroencephalography (EEG) and functional neuro-infrared spectroscopy (fNIRS)

greater neural commitment or attention to the sounds of their native tongue rapidly increase their language learning (Perszyk & Waxman, 2019). Whilst there is evidence that infants adapt flexibly to the sounds of new languages (Kuhl, 2007), it is still unknown whether or not early exposure and to what degree to non-native language/s, is sufficient to enable infants to link core cognitive capacities to the non-native language/s they hear. Recognising the incredible capability and capacity that infants possess for early learning requires a sea change in our consciousness. Historically, western knowledge paradigms have posited babies are passive actors in their own development. The recent revelations in infant neuroscience reveal that babies are far from passive; not only are they active participants they are leaders in their own learning within social learning dyads (Nguyen et al., 2020).

Pre-colonial ante and post-natal practices of tūpuna Māori align to at least an intrinsic understanding of these amazing capabilities. Oriori[39], for example, contained the richest oral language within te ao Māori and were composed specifically for infants to welcome them to te ao mārama[40]. Oriori conveyed vast amounts of tribal knowledge and hopes the iwi held for their future (Rameka et al., 2017). Like all waiata koroua[41], the oriori was highly rhythmic in nature, combining movement with harmonious chanting that shifted in range, pitch, tone, and meter. The links between neuronal entrainment to rhythm, singing and movement are emerging as important facilitators to achieving neural synchrony in infant, adult dyads (Markova et al, 2019). These fresh insights into how infant's shape their foundations for language and learning through tuning into rhythms within language has implications for ongoing social learning and development (Piazza et al., 2020).

As stated, the use of pneumonic devices such as rhythmic intonation or chant was a primary mechanism used by tūpuna Māori to transmit knowledge. Māori is an oral language, with various types of iconography depicted in woven materials, carvings, moko[42] lines and symbols relating to complex and ancient Māori knowledge systems. These cultural artifacts were not just decorative, they played a key role in prompting recall and provoking narrative, dialogue, and storytelling. For example, most pou[43] that grace the walls of wharenui[44] on marae depict tūpuna, atua and events in history. In te reo Māori the word for storytelling is *pakiwaitara* which literally translates to the stories pertaining to who is within the walls of the house. The use of pneumonic devices – iconography, rhythmic chanting, and movement in the provision of rich oral language to infants from birth, suggests that ancient Māori knowledge transmission aligns closely with the latest scientific understandings about the mechanisms involved in early langue aquisition and brain development. These multimodal approaches to teaching and learning within the ancient Māori world were highly effective in transmitting vast amounts of tribal knowledge intergenerationally. Tragically, these natural teaching practices were disrupted or suppressed because of colonisation. They were replaced instead by one-way didactic pedagogical approaches within unnatural contexts (classrooms) that were limiting of multimodal experiential learning and therefore poorly aligned to Māori children's learning styles and needs.

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[39]   to chant a lullaby
[40]   the world of light
[41]   traditional chants
[42]   traditional tattoo
[43]   post (carved)
[44]   ancestral house

Rau 3: Literacy and digital literacy

Digital literacy and fluency

Digital literacy and fluency are two broad concepts that describe the knowledge positions of learners in relation to their understanding, skill, and use of digital technologies. The Ministry of Education (2021) provide a useful definition of these terms on their website - *Te Whāriki Online*:

- *Digital literacy – builds on traditional literacy learning. It involves learning about **how** to use digital technologies and **what** to do with them.*
- *Digital fluency – includes digital literacy but is more than technical proficiency. It includes many social and dispositional skills necessary to use digital technologies wisely, safely, and respectfully. A digitally fluent person can choose **when** and articulate **why** a specific digital technology will achieve a particular purpose (no page number).*

The foundations for language and literacy begin in infancy, therefore, early childhood is an optimal time to start developing these competencies. In an increasingly digitised world, tamariki must start laying the foundations for the more sophisticated media and digital literacy they will require as adolescents and adults. Currently the concept of literacy is quite fixed within our curriculum, namely defined as print media. There is a tendency to view digital technologies as a practical resource rather than focusing on its versatility, mobility, and potential for generating and enhancing young children's communication. Phonic iPad apps and e-books, for example, can reinforce early phonics instruction and improve phonological awareness (Furlong, 2021). These apps could be utilised as tools to support child-led, triadic interactions and engagement with adults. Multiliteracies support diverse and open perspectives and the capacity to process and make sense of a broad range of information (Monilukutaito, 2017).

Traditional versus digital tools

An important advantage that digital resources have over traditional nondigital resources is their multimodal capacity (i.e., animation, images, print, sound). Children make meaning through multi-modal stimuli (text, pictures, words, music, colour, gesture and movement), strengthening and broadening their understanding of a particular construct by exploring it through multiple modes (International Literacy Association Early Literacy Committee, 2019). This view is often not shared by current educational curricula, which privileges written modes of expression and meaning making. Studies show that when given the opportunity, children make conscious decisions about the ways in which they express different meaning, and that these choices reflect their identity, family background, and cultural heritage (Kucirkova, 2017).

There are strong arguments for and against the use of traditional versus technological literacy media. Multimedia digital technologies with their rich array of possibilities for expression, disrupt the traditional paper-based paradigm. Proponents who lean toward the anti-screentime arguments, warn about the over exposure of young children to technology, and the American Academy of Pediatrics advocates for no exposure to digital technology for children under 18 months of age. Advocates for increased digital exposure argue today's children are *digital natives*[45] growing up in an increasingly digitised world and as such digital skill development is increasingly important to their future success.

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[45] digital natives are people who have grown up under the ubiquitous influence of the internet and other modern information technologies

The International Literacy Association (2019) in their report, *Digital Resources in Early Childhood Literacy Development*, opened their report with a provocative but unequivocal position statement on the use of digital resources in children's language and literacy skill development:

> *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 (p.1).*

Studies comparing traditional reading and e-reading showed no difference in recall quality, but interactive warmth was lower for e-reading as measured by postural synchrony[46]. Postural synchrony was found to be impacted by the position of the device, i.e., if placed on a table with an adult controlling the mouse or keys. The researchers also inferred that desktop devices had the potential to limit child agency or shared control over the interaction (Tarasuik et al., 2018).

Integrating digital technologies into early learning curricula

The Auckland Kindergarten Association are proactive in integrating digital technologies within the kindergarten environment, aligning to the updated early childhood education (ECE) curriculum Te Whāriki and the Digital Technologies and Hangarau Matihiko content in The New Zealand Curriculum (Education Central, 2019). In a recent article for Education Central (2019), Lyn Granshaw, a digital technologies education specialist identified multiple benefits to the use of digital technologies in early learning:

- *children are better engaged in their learning and able to express themselves through digital media*
- *the relationship between kindergarten and home is strengthened through digital platforms for documenting, sharing and celebrating learning success and progress*
- *children are growing into confident, capability digital citizens through positive, age-appropriate messaging (Adapted from Education Central, 2019).*

Technological innovations can drive pedagogical paradigm shifts, and these shifts are beginning to be seen within early education settings. The ability for children as young as 3 years to physically engage with hand-held devices (tap and swipe) have been demonstrated (Marsh et al., 2015; Vatavu et al., 2015), opening up possibilities for child-led interactive learning. The ubiquity of these devices also enables learning to be extended outside of formal learning environments (Erstad, 2012). With a large proportion of children failing to reach age-appropriate targets for reading and writing skills by age 10 to 11 years (Ministry of Education, 2021; National Center for Education Statistics, 2021), leveraging mobile touchscreen devices could have a significant impact in supporting the development of language and literacy skills in both first and additional languages.

The screentime debate

Many countries have policy statements relating to digital technologies and children's learning, (Early Childhood Australia, 2018; National Association for the Education of Young Children & the Fred Rogers Centre, 2012; Scottish Government, 2013; U.S. Department of Education & U.S. Department of Health and

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[46] postural synchrony – how an adult and child position themselves in relation to a book or other shared stimuli

Human Services, 2016). Common threads have been identified by the International Literacy Association (2019) and include:

- *Selection of high-quality digital media conveying content that supports curricular and learning goals and includes minimal distractors (e.g., ads, links that take users away from a site)*
- *Integration of digital technologies in ways that complement and enhance learning with other essential materials and activities*
- *Use of technology that supports development of creativity, exploration, collaboration, problem solving, and knowledge development*
- *Use of technology to strengthen home–school connections*
- *Access to assistive technologies to support equitable opportunities for learning (p.3).*

However, there appears to be a dearth of research that explores young children's experiences with interactive, hand-held devices. Most studies on screen time do not differentiate between children's interactive versus passive engagement (i.e., using a hand-held device versus watching television) with digital media, nor do they differentiate between content or programing. Further, the majority of studies do not account for the directional relationship between poor social, intellectual and physical developmental outcomes and screentime. Madigan et al., (2019) studied the effects of screentime on children's performance on a Developmental Screening Test (DST) and found that it was unclear whether low performance on the DST was a result of excessive screentime, or whether children with developmental challenges received more screentime as a result of (and to modulate) their challenging behaviours. This supports the finding of Radesky et al., (2014) that children with learning or behavioural difficulties receive more screen time than children without these challenges.
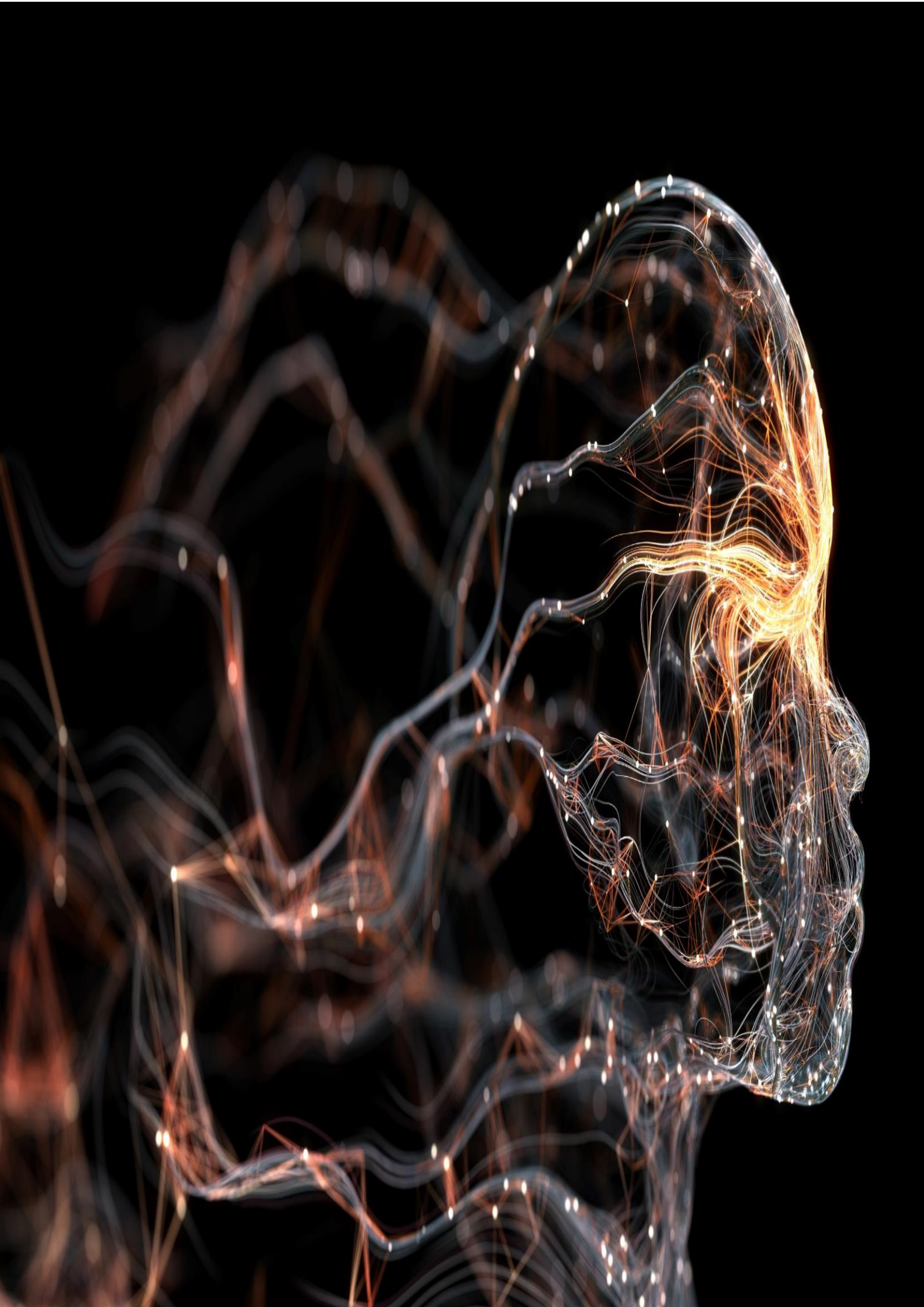
Whilst further research is required to fully understand these issues and their underlying causation, consistently the advantages of parental or adult/child interactive, co-exploration of digital technologies have been documented. Parent modeling of responsiveness to an on-screen speaker supported children's learning of new words via a virtual speaker (as a source of new language) when social cues were also provided by the parent as a co-viewer. Conversely children learnt fewer words when presented with the virtual speaker in the absence of authentic contingent social cues, (Strouse et al., 2018). Moreover, parents who collaborate in digital activities with their children create a safer online environment without preventing use or hindering child agency and learning. This helps young children acquire the skills to mitigate and manage associated risks with technology use (Livingstone et al., 2017).

The digital divides

Information technology (IT) presents numerous personal, economic, social, and cultural opportunities, such as access to employment, knowledge, social connection, communication and services, however not everyone benefits equally (OECD Publishing, 2018). Translating digital access into offline advantage strongly depends on an individuals' digital skills, literacy and fluency and motivations for use which can influence and be influenced by contextual factors such as social and economic status (Helsper et al., 2015; Helsper, 2017). Disparities between and within countries exist in relation to digital access, skill and use, and these disparities lead to increasing inequality in IT outcomes (Helsper et al., 2015). The available literature suggests that despite the unlimited potential of innovative digital learning technologies to improve learning outcomes they can also contribute to and accentuate existing digital divides (Parr & Ward, 2005). Wei et al., (2011) caution that, as we increase our adoption of digital tools and technologies, digital divides may increase based on access, equitable capabilities and learning outcomes with associated impact on cultural, social and economic wellbeing. Finally, Covid-19 has deepened equity gaps in educational outcomes, especially for children from

lower socioeconomic backgrounds; with more than 80 % of children from these households failing to reach milestones in reading (Gray, 2021).

The work of policy makers, economists, IT designers and other scientists should be concerned with the impact of digital inequalities across a broad range of outcomes connected to life chances and life trajectories. How digital inequalities manifest to impact wellbeing is unclear across individual and macro-level domains, i.e., life course, gender, race, class, health, economic and social factors (Robinson et al., 2015).

Rau 4: The potential of AI and voice recognition technology in early language acquisition and digital literacy development

The global shift to remote learning has created a profound sense of urgency to rethink how children interact with technology and what they can expect from those interactions … (Dr. Martyn Farrows, CEO of SoapBox Labs).

The field of Mobile Assisted Language Learning (MALL) has generated promising insights on language learning using digital technologies for adult learners (Lin & Lin, 2019; Sung, Chang, & Yang, 2015). Emerging research on mobile, touchscreen devices such as tablets and smartphones with adults and children suggests that these now ubiquitous tools can support language skills too (Godwin-Jones, 2017; Neumann & Neumann, 2017).

Voice recognition technology and AI in language learning

voice recognition technology is based on big data-searching language corpora to find matching patterns in order to convert audio to written text. However, it cannot analyse audio semantically, parse and analyse language, nor can it assess meaning or coherence - it merely transcribes speech (Carrier, 2017). However, coupling voice recognition technology with deep machine learning can bridge some of these limitations. The combination of voice recognition and intelligent machine learning can create immersive and authentic contexts allowing language learners to have social interaction in real-life like situations (e.g., Nicolaidou et al., 2021). The use of Artificial Intelligence (AI) in language learning has been slow in development, especially in the area of designing language learning for children. Up until recently language learning apps employing AI did not include the full computational power that is now available in AI systems, i.e., deep and machine learning (Pickhart, 2020). Potential reasons for the lag have been a failure the earlier models to integrate the flexibility and versatility of human interactions and a larger challenge involving designing language technologies for use with children.

Children's vocalisations differ substantially from adults, whereas most machine learning has been modelled on adult communication. Children have shorter vocal cords, and their vocal tracts are narrower, meaning they produce very different frequencies in pitch and tone to adults;they also do not follow adult vocal rules - over pronouncing, accentuating and punctuating speech very differently from adults (Scanlon, 2021). Dr Patricia Scanlon, the founder of SoapBox Labs, a Dublin-based Tech company, has developed speech-recognition technology that is modeled specifically for children based on the diversity of their vocal ranges and patterns. The software is able to process children's voices (differentiating between accents and dialects) within the complexities of their vocal range and within a busy playground or classroom to a high degree of accuracy. Accuracy is a major factor in designing AI and voice recognition technologies for language and literacy learning. Large data sets that can incorporate a high degree of nuanced and variable information can improve accuracy. False negatives and positives provide false affirmation - telling a child they are right when they are not, or worse, telling them they're wrong when they are right. Both scenarios have implications for a child's confidence, trust and learning (Scanlon 2021).

We have learned how interactive engagement or serve and return between infants and adults, supports healthy brain and language development. Given children's developing cognitive and language abilities, it is vital that effective adult-child communication strategies be integrated into the design of technologies intended for use by and with young children for the purposes of language development. These affordances in design should take account of non-verbal cues. Children frequently avoid responding to conversational prompts that they perceive to be too difficult and tend to rely on non-verbal expressions e.g., gestures such as shrugging or facial expressions like frowning. Therefore, technology designers need to carefully consider

the most appropriate way to respond to a child's lack of verbal input. In a recent study, Xu and Brahnam et al., (2021) found that the overwhelming majority of apps-initiated dialogue cycles using prompts that restricted either the length or scope of children's responses (i.e., multiple-choice prompts, repetition prompts, and one word response prompts). Of the apps surveyed, 116 out of 143 (81.1%), utilised restrictive prompts.

Further research is required in the area of affordances for communication strategies that could be incorporated in voice-based apps (Xu and Branham et al., 2021). Literature on serve and return provides a useful framework for guiding developer's understanding of effective feedback strategies to support children's language development. It is well documented that parents tend to produce structured dialogues when engaging with very young children, often highly repetitive and include clusters of partial self-repetitions (Kuntay & Slobin, 1996). At the Massachusetts Institute of Technology, computational scientists are modeling language learning from captioned-video segments of children interacting and acquiring knowledge naturally within their environment. In mimicking how children acquire language naturally, a semantic parser is able to observe the videos and associate the words with objects and actions, improving accuracy in context and meaning making (Ross et al., 2018). Lastly, there are other sociolinguistic and developmental factors that require further consideration when designing and developing AI and voice recognition technologies for children such as context and choice of materials across ages and stages of development, e.g., formal vs. informal contexts, group versus sole use, guided or independent learning, ability levels, socioeconomic context, and learning styles (Zosh et al. 2018).

Whilst the technology is still in its experimental stages, future apps will be able to interact, tell stories, teach vocabularies, engage children in games, and talk about everyday experiences with greater reliability, accuracy and human-like qualities. Designing technology that can adjust to children's response patterns and incorporate complex and more sophisticated dialogue flows that accommodate a child's variable communication patterns are important development goals (Shamir et al., 2012; van Daal & Sandvik, 2013; Parish-Morris et al., 2013; Salmon, 2014; Xu et al., 2021; OECD, 2018). However, there remains globally variable distrust in AI systems. Studies into acceptability in the UK and US, show parents are not as receptive to the use of AI with their children in certain contexts, whereas in India, China and Brazil, parents tend to be less skeptical (Perucica, 2022). Security concerns and risks abounded after an online Cloudpet was breached and the private information of millions of children, including photos and voice recordings were accessed. A critical issue in future design is the protection of children's data and their data sovereignty rights. Until parental safety concerns are allayed, skepticism, at least in some countries is likely to linger and robust policies are needed international and nationally to ensure safe design and use of AI and voice recognition technology. Despite concerns, the proponents of these technologies look to the potential benefits and realities of rapid digitisation, whereby these technologies will revolutionise every facet of our future lives; it is predicted that by 2065, 65% of today's children will be working in jobs that are yet to be created (Perucica, 2022). The potential to leverage voice recognition technology, AI and big data in language acquisition is both exciting and challenging. Challenging because to achieve it requires engagement and interface across multiple interdisciplinary fields – technological design and computational linguists, human studies, cognitive science, neuroscience and education.

The impact of COVID on technology development

Part of adapting to the 'new normal' in the Covid climate has seen digital technologies playing an ever more critical role in children's learning. An additional new direction has been to integrate mobile assisted language learning (MALL) with data driven and AI-inspired technologies, such as automatic speech recognition, natural language processing (NLP), and image recognition resulting in many new web-based tools or apps (e.g., Chen et al., 2020; Shadiev et al., 2020).

Whiriwhiria – integration, discussion, and conclusion

The Pā Harakeke conceptual framework provided a useful framework with which to review the broad range of literature represented within this review, allowing for dynamic exploration and analysis of the selected material. The review has illuminated the interrelated and complex nature of these foci providing a deeper understanding of the issues and factors relating to te reo Māori language acquisition, digital literacy and the potential role that AI and voice recognition technology can play in language acquisition and early mediated introduction to digital technology for young children. Further insights into the relationship between each rau and how they individually and collectively impact on the rito can be garnered through integrating and discussing the material. Again, in the interests of recentering Māori epistemological approaches, we take a Kaupapa Māori approach to the integration and discussion of the literature.

Data integration through a Kaupapa Māori lens

Data integration is an ancient human practice that has been employed by indigenous peoples for centuries to understand their social realities. It is evident that Māori possessed a strong history of empiricism and abstract reasoning from exploring the natural world and through intergenerational knowledge transmission. It is well documented that our tūpuna actively observed and examined the physical world around them, studying and analysing the cosmos and their natural environment (Barton & Fairhall, 1995). From time immemorial our ancestors were able to weigh complex information from a range of varied and diverse sources, through naturalistic observation, experimentation and replication. Using critical analysis of relevant data, along with profound logic and reasoning our tūpuna went through a process of what Weick, (1989) referred to as 'theory building' (p.522).

Overall, the literature supports the authors' theory that voice recognition technology combined with AI deep and machine learning has the potential to support te reo Māori language acquisition in young children under 5 within their home environment. Furthermore, intelligent interactive technology can be used to mediate child-adult interactions, where co-exploration supports safer exploration and exposure to technology for pre-school age tamariki. Increased understanding of how children acquire language through neural entrainment to rhythms, song and movement, and through interpersonal neural synchrony within child-adult interactions, should inform the future design and development of such technology. Further, that the design and development of AI and voice recognition technology-based apps for pre-school age children should follow strict international and national policy guidelines.

New insights through hyper scanning techniques are informing our understanding of how children acquire language and the importance of native language learning to their enculturation and early cognition. Designers should consider including the following design features to provide affordances that support a child's language learning and enculturation, whilst providing parents with increased assurance and acceptance of smart technology:

- security and data protection for Cloud-based processing
- limiting false negatives and false positives through the use of large data sets
- minimising the use of restrictive prompts to facilitate conversation flow
- improving the accuracy of context and meaning making through the use of high-quality captioned video
- cultural iconography and animations that prompt dialogue and storytelling
- rhythmic sounds, traditional chants and intonements that support neural entrainment
- accessibility and manipulation of on-screen media via touchscreens that offer multi-modal learning experiences, promote child agency and facilitate postural synchrony to enhance INS

- unintrusive, affordable, user-friendly platforms

The history of te reo Māori language loss and reclamation in this country provides stark evidence of the undervaluing and lack of protective action by successive governments to address the vulnerable place of the Māori language. Evidence that strong links to language, culture and identity have proven benefits for rangatahi Māori, including improved educational outcomes, should compel this and future governments to urgently implement the strategies of Te Maihi Karauna to hasten language revival. Reversing language shift is a multi-generational task that requires all people in Aotearoa to do their bit to achieve the audacious goals outlined in the Crown's Māori Language Strategy. The knowledge that only 1 in 6 Māori can currently speak te reo Māori to a high degree of fluency illuminates the predicament for the vast majority of pēpi Māori who are born into language environments that don't support the foundational development for native language learning. The promise of combining voice recognition technology and AI to support parents with limited proficiency in the Māori language to increase the amount and quality of te reo Māori within the home is an exciting proposition for the future.

Future research considerations

Fixed notions and traditional understandings of language and literacy development need to be reconciled with the potential of digital technologies to support children's early learning. Future research is required to investigate the potentiality of children's engagement in digital literacy practices; this includes taking account of e-safety concerns, perceptions that digital devices are disruptors rather than enablers to learning and factors that contribute to the digital divide such as digital access, affordability, and capability. Investigating the enablers and inhibitors to enhancing digital literacy in the early years is an urgent priority. Current evidence suggests that despite concerns about the impact of technology on attention and socialisation, meaningful use of high-quality digital resources is essential in preparing young children for long-term academic success.

Screens are ubiquitous in the modern-day lives of tamariki. Future research should be undertaken to further our understanding of the directional association and correlation between screen time and infant/child development. While AI and voice recognition technology-based apps have educational potential, the field must continue to investigate under what circumstances and in which contexts they are being used. The type of material presented to children needs to take account of developmental, environmental and social factor – age, ability, learning styles, formal vs. informal, group versus sole use, mediated or independent learning ability levels and socioeconomic context.

Limited research exploring young children's experiences with interactive, hand-held devices should be addressed. Most studies on screen time do not differentiate between children's interactive versus passive engagement with digital media, nor do they differentiate content. Further, the majority of studies do not account for the directional relationship between poor social, intellectual and physical developmental outcomes and screentime. Again, these challenges should be the target for future study.

Fresh insights into how infant's shape the foundations for language and learning through tuning into rhythms within their language environment has implications for ongoing social learning and development. Whilst these insights are providing greater clarity, it is still unknown whether or not exposure to non-native language/s and to what degree, is sufficient to enable infants to link core cognitive capacities to the non-native language/s they hear and should be the focus of future research.

The early teaching practices of tūpuna Māori align with emerging scientific understandings gained through hyper-scanning that rhythm is an important factor in infant language acquisition. Future studies could shed

light on the role of rhythm in traditional knowledge transmission; particularly, exploring the role Māori pneumonic devices played in early language acquisition and enculturation.

Finally, in the Covid era, there is an urgent need to develop technology that can significantly improve educational outcomes for tamariki Māori, whilst developing their digital literacy and fluency skills. Designing and prototyping a digital app that can support parents to whāngai[47] te reo Māori to their pēpi in the first 1000 days of life is a pressing research goal.

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[47]   to feed, nourish

Glossary

Aotearoa	New Zealand
Atua	gods, deity
Awhi rito	guards' stems, protector of the rito
Hapū	sub-tribe
Iwi	tribe
Karakia	blessing or prayer in the form of incantation or invocation
Kaupapa	project, subject, topic, theme, issue
Kaupapa Māori	Māori principles
Kōhanga	nest
Kōhanga reo	Māori language preschool
Koroua	Elder (man)
Maihi Karauna	Crown Māori Language Strategy
Māoritanga	Māori culture, ways of knowing and being
Marae	area in front of an ancestral house
Mātauranga Māori	Māori knowledge
Mātua	parent
Moko	traditional tattoo
Oriori	to chant a lullaby
Pākehā	early European settlers and their descendants
Pā harakeke	flax bush
Pakiwaitara	story, narrative
Pēpi Māori	Māori infant/s
Pou	post (carved)
Puna mātauranga	wellspring of Māori indigenous knowledge
Rā	day
Rangatahi	young people, teenagers
Rangatiratanga	self-determination, authority, sovereignty
Rau	leave, leaf
Rito	central shoot or leaf
Tamariki	children
Taiao	environment
Te ao Māori	the Māori world
Te ao Mārama	the world of light
Te reo Māori	the Māori language
Te reo o te pā harakeke	Language of the flax bush
Taonga	treasure
Tupuna	ancestors
Waiata	song
Waiata koroua	old chant
Whakapapa	genealogy, ancestry
Whānau	family
Whāngai	to feed, nourish
Whare	house
Wharenui	ancestral house
Whiriwhiria	to weave or discuss
Wiki	week

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