

# Prototyping Digital Taonga: Considerations for Digital Representation, Interaction, and Access

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Taonga Māori (Māori treasures) provide vitality, inspiration, and resilience to their community. Digital representations of taonga Māori offer opportunities to interact with and share taonga that may not be physically accessible due to being held in museums or private collections, or due to the people with connections to the taonga residing away from their communities. However, it is not clear how taonga should be represented digitally, and whether current tools can support appropriate interactions with taonga. This paper sets out a collaborative research approach employing prototypes to support conversations with Rongowhakaata Iwi Trust in Aotearoa New Zealand about their needs and priorities around digital taonga. These conversations are part of an ongoing research project between the Trust and university academics in which we aim to design infrastructure and processes that align with traditional knowledge practices and tribal worldviews. Through these conversations, we were able to identify design considerations for digitising taonga as well as for the software applications in which the digital representations of taonga may be embedded.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)**; **Virtual reality**; **Graphical user interfaces**;

Additional Key Words and Phrases: taonga Māori, prototyping, Indigenous communities, Indigenous data and systems

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## 1 INTRODUCTION

For the Māori of Aotearoa New Zealand, taonga<sup>1</sup> — treasures — provide vitality, inspiration, and resilience to their community. Despite the potential of digital technologies to enhance access to taonga, there are critical concerns about how these cultural treasures should be represented in digital form and how the nuances of Māori worldviews, and

<sup>1</sup>A glossary of Te Reo Māori terms used in this paper are included in [Appendix A](#). Definitions are based on Te Aka Māori Dictionary at <https://maoridictionary.co.nz>

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cultural practices should affect the design of digital systems. This also raises questions about the appropriateness of existing digital tools and platforms for representing taonga. Designing digital representations and surrounding infrastructure that are respectful, accurate, and aligned with the cultural values of Māori communities is essential.

This paper explores these issues as they emerged from discussions on a collaborative research project between Rongowhakaata Iwi Trust in Aotearoa New Zealand and academic researchers. This paper reports on our early relationship-building activities between Iwi Trust members and the academics, where we created three functional interactive prototypes to collaboratively explore the above questions. The project employs prototypes as a means to engage in meaningful conversations with the Iwi Trust about their needs and priorities regarding digital taonga. These conversations aim to inform the future design of digital infrastructure and processes that are in harmony with Māori traditional knowledge practices and tribal worldviews. By identifying the design considerations for digitising taonga and embedding them in software applications, this work contributes to the development of culturally appropriate digital tools that can support the continued vitality and resilience of Māori communities. Our aims with including the prototypes in the conversations with Iwi Trust members were to engage in a process of knowledge exchange where the academics demonstrated what is possible in the software, the Iwi Trust members interacted with the prototypes, and then the issues that were sparked from that experience were discussed and reflected on together. We present (in [section 4](#)) the three prototypes: i) Kete – basket ii) Hoe – paddle iii) Aro – Track and Trace Taonga, the themes of explorations, and how Iwi Trust members responded to those. In [section 6](#), we discuss the key ideas and design considerations that resulted from this engagement. We believe that working together with Indigenous communities (iwi community in our case) to address and consider these questions, allows for more resilient outcomes that will persist over time. It is important to note that customs, values, and knowledge differ between regions and iwi throughout NZ and our project is in collaboration with one specific tribal community. The project is guided by the principles of Te Tiriti (the Treaty of Waitangi).

## 2 RELATED WORK

Here we provide some related work to contextualise the project and the methods.

### 2.1 Māori and technology

Māori have a long history of adopting new technologies, but also of innovating and developing technologies that suit their specific needs and allow for the expression of their culture and identity [19]. For example, Sandoval et al. [32] used the Haka (a traditional war dance) as a case study for coining the new field of ‘Robotology’ as “the study of the impact of Robotics on different levels of human experience.” Nao Robots have also been programmed to preserve the Haka [30]. Virtual and augmented reality technologies have been utilised to preserve traditions such as the Hongi (a traditional Māori greeting) [15], traditional stories [36], and Pōwhiri (a traditional Māori welcoming ceremony) [22]. These examples suggest that there is ongoing interest in leveraging novel technologies in Māori cultural practices specifically in the context of reconnecting to this unique culture, which sits alongside emerging research on cross-cultural co-design with Indigenous groups such as Sámi (e.g. [26]) and Aboriginal and Torres Strait Island communities (e.g. [20]). Existing work highlights potential benefits and opens up new questions that need to be explored further around navigating the virtualisation of traditional practices and the integration of Kaupapa Māori research approaches as part of technological integration [22] [27]. Despite this, it would be naive not to acknowledge the tensions that exist between the Western and Māori worldviews [2, 14] and the ongoing work in decolonising design practice (e.g. [18] and [3]).

## 2.2 Digitising Cultural Heritage and Māori

An increasingly popular use case of modern technologies is the digital recreation of taonga (treasures). The digitisation of cultural heritage artefacts has been ongoing since the 1970s, with institutions increasingly adopting digitisation programs to enhance access to cultural materials [35]. Early digitisation efforts focused on preserving and providing access to digital representations of objects [35], in particular on how to maintain, digitise, and preserve access to images and documents [25, 39], with metadata schemas and standards playing a crucial role in organising and providing access to digital objects in cultural heritage libraries [28]. This has led to guidance on key issues that need to be considered such as security access and availability, longevity, viability, obsolescence, redundancy and diversity, fixity, provenance and audit trails, etc. Another challenge to long-term storage is sometimes referred to as “format rot” where even if the data is migrated, the bitstream cannot be interpreted because the software is obsolete [29]. While digital technologies offer ways to preserve and promote Indigenous knowledge [5, 6], they also raise concerns about ownership, control, and access to cultural property [34]. In non-Māori contexts relating to cultural heritage, Ciolfi et al. [7] provide a framework for reflection on how issues including roles and design decisions play out in such collaborative work. This indicates that there is still work to be done on navigating these concerns in technology development processes.

## 3 THE PROJECT

The Digital Taonga Project is a collaboration between Rongowhakaata Iwi Trust (RIT) and academics from Te Herenga Waka-Victoria University of Wellington in Aotearoa New Zealand. The academic team comprises one Māori and five Pākehā (people of non-Māori or Polynesian descent) researchers specialising in Software Engineering, Cybersecurity, and Human-Computer Interaction. The RIT representation on the project comprises four core members of RIT (including its senior leadership) who consistently engage with the academic team and who intermittently invite other people who work for RIT or are part of their wider community to contribute to discussions throughout the project. In this paper, we use the term *RIT members* to refer to the core group who participated in the discussions and who interacted with the prototypes described in the coming sections. We consider both the RIT members and the academic team as *project team members*, sometimes just referred to as the *team*.

The project aims to explore how recent technological advancements like Virtual Reality (VR), the Blockchain, and Artificial Intelligence can be used to digitise taonga Māori (Māori treasures) and ensure the tribe’s future vitality. The project was motivated by the Iwi’s goal of repatriating taonga held in museums and the potential use of 3D models to maintain access to taonga when physical access is not possible. The project is set up to allow for collaborative exploration of available options and considerations for digitising taonga and co-designing the surrounding infrastructure and processes that are necessary for the Iwi to have full governorship and ownership of their digital taonga into the future. Three key research questions were identified: i) what is the appropriate process for digitising taonga Māori, and what aspects of taonga need to be digitised; ii) what are the possible applications of such digitisation; iii) what are issues or concerns around ownership, access, and sovereignty that need to be taken into consideration.

The team adopted a workshop-based approach, using interactive prototypes to facilitate discussions with the RIT members. These functional prototypes included a basket (Kete), a paddle (Hoe), and a tracking system (Aro). The prototypes served as tools for knowledge exchange between the academics and RIT members, helping the researchers to better understand the cultural significance of taonga and assess the suitability of current technology for digitisation. It is important to note that with this work we were not looking to validate our design decisions, but to bridge our world (Westernised, academic) and the world of the iwi through externalising the knowledge in the academic team and

inviting a reflection back from the RIT members as experts in Te Ao Māori (the Māori worldview). In this way, the prototypes played a mediating role in the collaborative knowledge exchange and knowledge sharing between project team members [24] [23].

Before we present the prototypes and our design considerations we want to acknowledge that as pākeha and researchers in a university that primarily operates in traditional Westernised ways of knowledge, our thinking, decision-making, and discussions move between Westernised technological understandings and Te Ao Māori. The non-Māori researchers in our team started the project with a very naïve view of what taonga were, aligning more with the early Western ideas of taonga as important objects to Iwi – importance strongly tied up with economic value – and with a rather shallow appreciation of their cultural role. The prototypes presented in [section 4](#) reflect that initial understanding. We show in [section 6](#) how the prototypes and conversations around them helped to evolve our understanding and assess the suitability for digitising taonga using current technology. All reactions to the prototypes are constructed from our hand-written meeting notes. All direct quotes are from the co-author. No other data were collected. Earlier versions of this paper were shared with RIT members who provided feedback, which has been integrated in this version. The implications of this paper’s publication in de-anonymised form were discussed between project team members.

## 4 PROTOTYPES

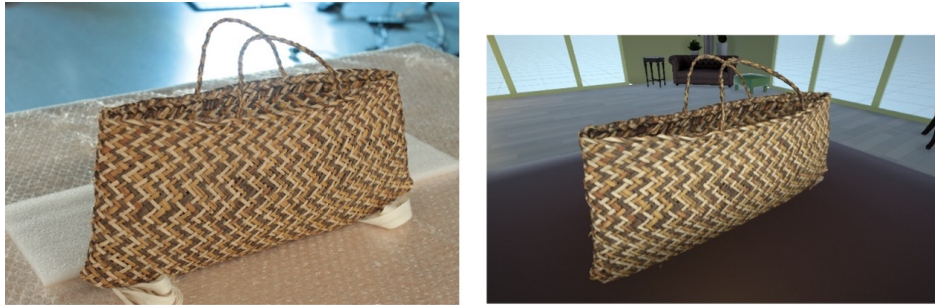
We developed three prototypes. Two were VR prototypes – Kete (see [subsection 4.1](#)) and Hoe (see [subsection 4.2](#)) – using the Unity engine to support and inform conversations around how digital representation of taonga and their stories could be achieved and what are appropriate ways to interact with these digital artefacts. The third was a mobile application – Aro (see [subsection 4.3](#)) – developed for Android systems to explore and guide discussion around viable technology solutions that can ensure ownership and protection of taonga for the Iwi. All three prototypes were presented and discussed as part of an early co-design workshop attended by the researchers and RIT members. In the next subsections, we provide a brief description of each prototype.

### 4.1 Kete – basket

This VR prototype is a kete, or basket, that is traditionally used for collecting and storing kai (food) such as kūmara (sweet potato) – see [Figure 1](#). This kete is an example of a taonga that is not part of a museum collection, but instead looked after by the whānau and kept with them in their home. This specific kete was gifted to the wife of a Trust member by another tribe and is being used as a personal accessory worn to important gatherings and tribal huis (meetings). It is woven with pīngao (sedge). The VR experience presented the three-dimensional virtual kete fifteen times larger than in real life. This allowed users to view the patterns, colours, and textures in the weaving and freely move around the virtual object.

### 4.2 Hoe – paddle

The second VR prototype is a hoe, or waka paddle, pictured in [Figure 2](#), which is currently held in an overseas museum collection. The Iwi were recently given a brief window to see a group of these taonga while they were on display in Tairāwhiti Museum, Aotearoa New Zealand. Despite being their rightful owners, the Iwi were unable to keep the hoe in Aotearoa New Zealand. In our VR prototype, upon launching the application, users find themselves in a low-fidelity museum environment with a hoe in the centre, presented with an information plaque next to it explaining its history. This was intended to replicate a typical museum environment where artefacts can only be passively viewed from a distance. However, users quickly learn that there is no glass between them and the hoe and they are free to get as close



(a) A photograph of the kete propped up and placed on a table during the photogrammetry session. (b) The 3D VR kete created from the photographs, such as the one shown in 1a.

Fig. 1. Kete — basket



Fig. 2. An example of how taonga can be replicated and revitalised in a digital form. (Left): Several hoe belonging to Iwi displayed in Tairāwhiti Museum. (Right): A 3D replica of one of these hoe rendered in VR.

as they like to it. Users can pick the hoe up at this point by squeezing the grips on their controller; upon doing so, the walls around them slowly fade away, revealing an empty ocean and starting an audio narration of the hoe’s history. Users can now use the hoe to propel themselves through the water by using a paddling motion, restoring its original function and allowing the user to learn its history through the audio. The purpose of this prototype was to demonstrate the potential of digitised taonga beyond simple archiving. Many important artefacts are locked in museum archives or display cabinets, inaccessible to the public and even to their historical owners. We wanted to show that technology could be an empowering force in such scenarios, giving Māori the ability to interact with these taonga again and see them in their natural (and intended) context.

### 4.3 Aro — Track and Trace Taonga

A key issue that arose from our discussions about digital taonga is how they would be used, and more importantly, who would have access to them. This is pertinent to taonga on public display in museums; given how simple it has become to

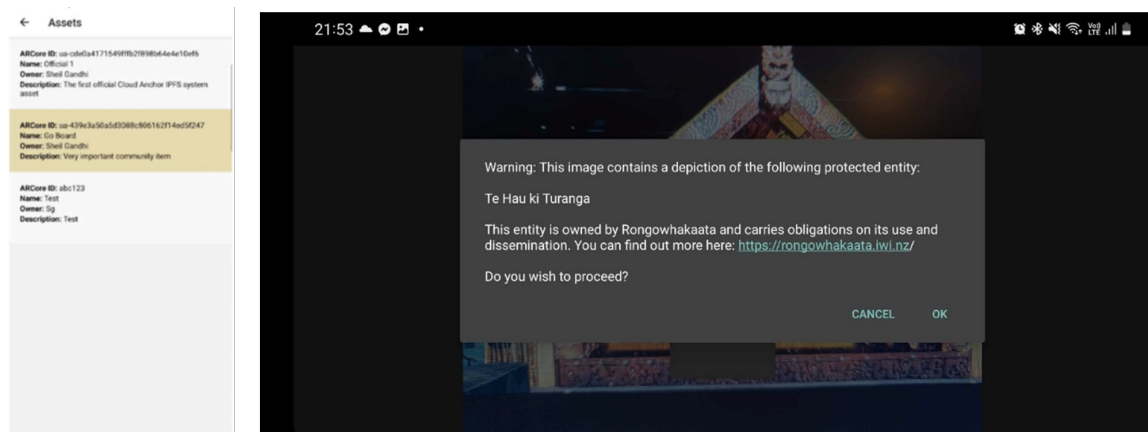


Fig. 3. Image illustrating a user interface for tracking digital images of assets (taonga) across online spaces. (Left): A list of taonga with associated metadata such as Name, Owner, Description. (Right): An example of how this metadata could be used to protect taonga. Upon trying to upload a photo of a whare whakairo (carved meeting house), the user is informed that it is a protected entity and has rules governing its use.

make 3D reconstructions with widely available mobile applications such as RealityScan [13] it has become impossible to know and keep track of how culturally significant artefacts are spread and represented online. The third prototype – Aro, meaning to notice or take heed – is based on a ‘track and trace’ model where the appearance and use of digital representations of taonga can be ‘tracked’ and ‘traced’ in online spaces. The prototype provides a mobile user interface to take a photo and upload it to an imaginary social media service. Upon uploading the photo, a message appears alerting the user that the photo includes a depiction of a whare whakairo (carved meeting house) and that by uploading the photo the user agrees to abide by all rules around how the digital image may be used. This message contains a link to the owners’ website where these rules are hosted. This is illustrated in Figure 3. The prototype assumes a technical infrastructure where taonga owners will create a digital signature of a physical taonga, by, for example, scanning the taonga using Google’s ARCore Cloud Anchors [12] and uploading the signature to an online register. The intention would be that any digital media including photographs, videos, and 3D models could then be automatically compared against this digital signature through trawling online sites and flagged as a digital representation of a taonga in the register, alerting the owners to its usage. Once aware of the representation’s existence, the owners could then take action if the usage of the taonga is outside the rules.

## 5 REACTIONS TO THE PROTOTYPES

The three functional prototypes were presented as part of an early co-design workshop attended by the project’s academic team and RIT members, and prompted varying reactions and far-reaching discussions on the day. The discussions that resulted from this workshop and included in this paper were continued in three further meetings between the project team members, and the prototypes continued to be used as points of reference between the project team. The next paragraph is a summarised overview of the reactions on the day of the workshop.

Interacting with the Kete prototype prompted RIT members to think about what a ‘taonga’ really is; is it the physical object that is important, or is it the stories and history surrounding it that give it its vitality? Other questions included what purposes can and should their digitisation serve, while also allowing for detailed inspection of the craftsmanship

that ultimately informs future generations and sustains the tribe's vitality. Importantly, the prototype raised questions about how personal, whānau and the Iwi histories and traditions can be upheld in the digital sphere. The Hoe prototype sparked a lot of enthusiasm due to its interactive element that allowed for it to be used as a paddle. Users were pleasantly surprised to be transported to the ocean by gripping the virtual hoe. Both young and older users quickly understood how to operate it in the VR environment and started paddling and taking turns competing with one another as if they were in a waka ama (outrigger canoe) race. The hoe also prompted ideas around how digital taonga can become educational tools that teach rangatahi (young Māori) about the taonga in a playful manner and inspire creativity to innovate further. Interacting with the Aro prototype prompted RIT members to comment on the economic opportunities of digital taonga in future scenarios where owners could charge for access to the digital versions. RIT members commented on the difficulties of creating a complete register of taonga due to their dispersal around the world and between whānau. In a surprising realisation (to the academics) RIT members identified that the Aro prototype imposes a gatekeeper role on the Iwi Trust and subsequently questioned whether controlling access to taonga was an appropriate function of the Trust.

## 6 DESIGN CONSIDERATIONS

Interacting with the three prototypes stimulated rich ongoing conversations in the follow-up meetings that culminated in three design considerations for digital taonga that the project team will continue investigating in the future. We elaborate on these below with the acknowledgment that they represent the academics' current understandings of taonga and Te Ao Māori, which are still very much an ongoing journey that is evolving through continuing engagement and co-design processes between the researchers and the RIT members.

### 6.1 Taonga, mauri, and tikanga

Taonga Māori as a concept is complex and can not be straightforwardly replicated in the digital realm. Dictionary definitions show the variety inherent in the term, which can refer to “property, goods, possession,” including “anything considered to be of value including socially or culturally valuable ... ideas and techniques” [9]. Essentially, taonga can refer to different things, from physical artefacts to ideas, processes, and even people. Taonga provide vitality, inspiration, and resilience to their community and connect people with their past, present, and future. It is obvious that one digital implementation of a taonga will not necessarily be applicable or transferable to another. As one of the RIT members explained: “*Taonga hold and carry information and mātauranga [knowledge] across generations – like time capsules (...) And include plants, language, knowledge, whakapapa [meaning genealogy], and ancestral technologies – they are living and not only relevant to the past or histories.*” In this respect the significance and value of taonga often stem from their practical function and everyday use, they being part of and connected with the whānau they belong to and the whānau's everyday life. The kete was discussed as one such example of taonga by one of the Iwi Trust members because it can be taken to the garden, filled with kai, and then taken to the whānau. It is not a physical object that is hidden away, kept safe, or preserved but rather, valued because it is used daily. This understanding of taonga is in contrast with the (Westernised) view of treasured, inanimate objects needing to be hidden away and/or kept in museums with handling minimised. In Te Ao Māori, often the best place for taonga intended to be used is in the kaitiaki (care/guardianship) of the whānau and the more you use it the more value it has. Further, taonga possess mauri (life force) that “imbues and animates all forms and things of the cosmos,” [16] and carries every generation's mauri building up value and power. Applying this philosophy has seen several rivers worldwide being granted legal rights (and receiving better protection),

including the Whanganui River in Aotearoa New Zealand [17]. Any digitisation of taonga needs to acknowledge and respect the mauri and consider how its value through use may be maintained in the digital sphere.

Tikanga (protocols) guide behaviour in appropriate ways and constitute a set of practices and principles that have evolved over time, and are passed down through generations, such as the right time to harvest natural resources, ways to conduct interpersonal relationships, and pertinent to this research, how to work with taonga. When digital taonga are created there are still many questions about what are the correct protocols that should occur in the physical world during the digitisation process and which protocols apply in the digital world. For example, there has been recent work looking into appropriate tikanga regarding entry to a digital marae (tribal house) – normally access to a marae is only allowed for the local Iwi and anyone else that has attended the entry ceremony known as pōwhiri – by considering how a digital pōwhiri may look like and what should it involve [27]. Software developers and designers need to work closely with Māori on how to design software and interactions in ways that respect tikanga. In this project, we still have ongoing work in uncovering the tikanga around the cultural artefacts we are involved with, for example, is it appropriate to turn a hoe into a 3D model that can be ‘played’ with in VR? What level of playfulness is appropriate? Perhaps having a competitive waka (canoe) race is permissible whereas using the paddle as a weapon against an opponent is not. Creating interactional boundaries and limitations in the software so that digital taonga are not misused is possible from a technical perspective but given the nuanced and complex nature of taonga, there is significant socio-technical work that needs to accompany digitisation processes, as one solution will not fit all.

## 6.2 Taonga and identity are intertwined

From the discussions during the interactions with the Kete and Hoe prototypes, it was evident that details of the carvings and weaving patterns are extremely important as they are taonga themselves and cannot be considered separate from the artefacts they are part of or the people who made them. Therefore, capturing such details in the digital representation is essential in bringing meaning and value to the digital form. Discussions with Iwi Trust members have clarified that inspecting and touching the details of carvings, for example, are part of the process of learning the styles and techniques of the master carvers. Different tribes have different patterns or styles; that are instantly recognisable to those with this knowledge. “...it helps to facilitate our being in the world. Once you remove yourself from it it is not a taonga anymore.” Higher resolution photographs become possible with improved consumer camera technology, but the side-effect of the continual emergence of new technologies is that older technologies and older digital formats become obsolete. Future work will require considering ways to ensure access to the digital representations of taonga is maintained for years and generations to come.

The significance of the details of patterns in digital objects was also discussed in the interaction with the Aro prototype in that patterns should be protected from misappropriation and copying without acknowledging the creators. In our discussions with the Iwi Trust members, it was explained that when taonga like the kete gets worn out, a new kete is woven using the old patterns which then gets passed on to the children. This creates a continuity in the traditions and cultural and personal identity as the younger generations carry out the same practices that previous generations have carried out. The pattern that is woven or carved also carries a story or information, e.g., constellation patterns, which is why the details of the carvings and weaving patterns are taonga in their own right and essential to be included in the digital representation. As the old patterns are used when re-weaving or carving the technique is part of a weaver’s, or carver’s, personal expression and in this way connects to that person’s identity, and carries that forward revitalising the tribe/whānau.



Another consideration around digital taonga is that each taonga is considered to have whakapapa (genealogy) preserved in oral traditions and stories. The whakapapa tells of the origins of the taonga, the masters involved, and its role in historical events. Similarly, the source material (e.g. Pīngao or Kauri) has whakapapa that records where it was planted, moved to, holds access to the history within it (e.g. a pounamu (greenstone) pendant holds the names of all the people who have worn it) and is part of Māori people's identity, linking them back to their ancestors and providing the lifeforce for the future: "the kete lives on in its mātauranga and whakapapa and its mauri will live on. (...) it tells me who I am and helps me to understand and be strong in the world". In this respect, when considering how one can digitise taonga, the work goes beyond technical considerations and involves significant identity work [4] on the part of the taonga owners and community to fully understand and agree on the appropriate processes by which digitised taonga will construct, maintain, and/or adapt Māori identities. This identity work is a common outcome among grassroots communities as they work on integrating digital systems into their current practices [11]. Associating whakapapa with digital taonga is an ongoing theme of our work and while mere metadata overly simplifies these concepts, other avenues are still to be explored.

### 6.3 Respecting Māori Data Sovereignty: accessing and sharing digital taonga

A perceived benefit of digitising taonga is the potential for opening up access to taonga and facilitating sharing. Physical taonga can be geographically dispersed; some are held with whānau, sometimes in their home, and may not have been seen by other members of the Iwi for generations, and some are held in museums and galleries both in Aotearoa and around the world. Similar to Indigenous people in other parts of the world, Māori have physical taonga that has been taken from them and currently reside in museum collections around the world [33]. This has a great impact on Māori's ability to carry out their role as guardians of taonga and as rightful owners, who rely on the taonga to provide vitality, inspiration, and resilience to their community: "*Barriers to accessing taonga for Rongowhakaata impacts more than 'morale'. It impacts our well-being and our health, our expression of identity, our ability to communicate with our ancestors and access our ancestral knowledge(s) as well as our ability to care for and have agency over that knowledge.*"

Even when taonga are kept with the Iwi, these may be inaccessible for whānau who have moved out of the area, or overseas. Many Iwi members want to retain their connection to their Iwi and want their tamariki (children) to also have this connection, even when they are not able to visit their Marae or hometown. Creating a digital version of the taonga can help with this as it ensures that the taonga is available for Iwi members and others to view and possibly interact with. However, sharing taonga is not uncomplicated, as it is not always appropriate to share with everyone, or not all aspects of a taonga can be shared with everyone even within the same Iwi. This requires design considerations for how the visual fidelity of the 3D models, created through photogrammetry, relates to ownership and access. While a photo-realistic representation would be necessary for cataloguing purposes, as mentioned earlier, many taonga contain privileged tribal knowledge depicted through carvings, images, and even in the techniques used in their creation. In this respect, it is suggested that any digitisation process needs to consider whether a photo-realistic rendering is always appropriate, or whether lower fidelity models with these features removed could be created for scenarios where this private knowledge should be protected. Similarly, access to the high-fidelity digital representations needs to be regulated and any taonga that is made publicly available must be protected from exploitation, and monetary gain from those who have no attachment or claim. In the spirit of protecting the digital versions of physical taonga, our approach to the work in this project is to support the Iwi in taking ownership and control of the digitisation process itself. In accordance with our knowledge exchange practices, we recorded our process and created several tutorial videos for the Iwi on how to create their own 3D models. Due to the cultural significance of these artifacts, we believe it

is important that the process of digitising and preserving them should be transparent and that the kaitiaki (guardians) should be able to do so without becoming reliant for the digitisation of taonga on outsiders, and expose important cultural knowledge in the process.

Any sharing and access considerations are also directly linked with the need and obligation for any technological solution to respect and honour Māori Data Sovereignty. The concept of Māori Data Sovereignty recognises that Māori data should be governed by Māori. This allows for tribal sovereignty to be supported, and Māori and iwi aspirations realised [8]. Adhering to a Māori data sovereign state in a system may also include that any private details pertaining to iwi and their tūpuna (ancestors) remain private, shared only amongst who the whānau (family group) want to share with. One way to address this is to opt for solutions that follow the principle of least privilege – an information security concept that states that users are only granted access to specific data, resources, and applications that they need to complete a required task [31]. In this respect, access to those who wish to view the catalogue of taonga (treasures) online should be organised according to a hierarchy in which different groups of users would be allowed different levels of access to the taonga. The first level could allow public access, where limited information about the taonga is shared – for example, a photo accompanied by a brief description as you would encounter in a museum. The next level of access (requiring login credentials, set up by the Iwi) could allow the requestor more access to the artefact, for example, close-up imagery showing the carving designs in more detail and providing information about the carver, their whānau, and the date of carving. The final level of access allocated to Iwi Trust members and Rangatira (high-ranking officials within the Iwi), in their own Organisational Unit (OU) would allow for highly specialised information, such as VR/AR images of the taonga, and high-tech imagery that captures the strokes of the carving, effectively each master carver's signature. However, these levels of access control may be challenging for the Iwi to implement using the classic, Western access control models such as Role Based Access Control (RBAC) [10], which are individualist, conflict with the collectivist Māori worldview and do not provide a natural mapping to whakapapa (genealogy) relationships. This opens up opportunities for considering novel (decolonised) technological solutions more tailored to the needs and values of Indigenous data sovereignty.

## 7 CONCLUSION AND FUTURE WORK

Taonga Māori are complex artefacts connected to people, places, and histories. They embody traditions, cultural meanings, and a Māori approach to understanding the world. In academic research with Taonga Māori, we are obligated to engage with taonga not as mere objects to be replicated digitally, but as fully connected beings with life force, that are intricately connected with iwi and are playing active roles in passing on that embedded knowledge and understanding to those living today. How taonga are experienced, used, or shared can vary widely depending on what the taonga is and its place in the world. Therefore design considerations around their digitisation are complex and require methods that are led and sanctioned by (or at a minimum co-produced with) their rightful owners. For digital representations of taonga to truly function as digital taonga requires digital infrastructure built around it that allows for nuanced levels of access, upholds tikanga, and preserves whakapapa for future generations. While off-the-shelf solutions may partially address our design considerations, there is a clear need for designing and developing bespoke tools.

Future work will include working with RIT members to develop such an infrastructure, building upon the IndigiCloud prototype architecture [37], which demonstrates a practical implementation of locally controlled data infrastructure that meets principles of Māori Data Governance (MDGov) [21]. The IndigiCloud prototype, implemented at a local level, provides a tangible example of how to address the data protection requirements outlined in Pou #4 of the MDGov model. This pou focuses on ensuring that private, confidential, or sensitive information is safe and secure from external

threats and security breaches and emphasises the need to provide solutions that allow Māori to make their own risk assessments about the storage of Māori data.

Access control is a strongly related problem and any infrastructure will need to provide mechanisms that reflect the Iwi conceptualisation of who should have access to what, where, and when. We have built a small prototype web-based system for exploring the suitability of access control policies and found that Attribute Based Access Control (ABAC) [38] was able to capture a richer range of relationships than MAC or RBAC such as attributes of the requested object, requester and environmental conditions. A problem still with ABAC is the complexity of the policies and the need to explicitly detail possible relationships. Future work will also consider the more recent Semantic Based Access Control [1] that allows inference rules to be applied to simplify the policies making manageability easier.

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## A GLOSSARY OF TE REO MĀORI TERMS

**Aotearoa:** North Island - now used as the Māori name for New Zealand.

**Haka:** performance of the haka, posture dance – vigorous dances with actions and rhythmically shouted words. A general term for several types of such dances. <https://www.newzealand.com/nz/feature/haka/>.

**Hoe:** Paddle.

**Hongi:** to press noses in greeting.

**Hui:** Gathering, meeting, assembly, seminar, conference.

**Iwi:** Extended kinship group, tribe, nation, people, nationality, race - often refers to a large group of people descended from a common ancestor and associated with a distinct territory.

**Kai:** Food, meal.

**Kaitiaki:** Trustee, minder, guard, custodian, guardian, caregiver, keeper, steward.

**Kaitiakitanga:** Guardianship, stewardship, trusteeship, trustee.

**Kete:** Basket, kit.

**Mahi:** Work, activity.

**Māori:** Māori, Indigenous New Zealander, Indigenous person of Aotearoa/New Zealand – a new use of the word resulting from Pākehā contact in order to distinguish between people of Māori descent and the colonisers.

**Marae:** Meeting grounds, The marae is sacred to the living, and is a memorial to the dead. <https://www.awataha.co.nz/About+Us/What+is+a+Marae.html>

**Mātauranga:** Knowledge, wisdom, understanding, skill.

**Mauri:** Life principle, life force, vital essence, special nature, a material symbol of a life principle, source of emotions – the essential quality and vitality of a being or entity. Also used for a physical object, individual, ecosystem, or social group in which this essence is located.

**Pākehā:** New Zealander of non-Māori or Polynesian descent.

**Pīngao:** Golden sand sedge (a type of plant) – a native plant with golden-orange, polished, arching, narrow leaves which grows on sand dunes. Its dried leaves are used for weaving and ‘tukutuku’ panels for their bright yellow-orange colour.

**Pounamu:** Greenstone.

**Pou:** Support, supporter, stalwart, mentor, symbol of support, metaphoric post.

**Pōwhiri:** Invitation, rituals of encounter, welcome ceremony on a marae, welcome.

**Rangatahi:** Younger generation, youth.

**Rangatira:** High-ranking officials within the iwi, chief (male or female), chieftain, chieftainess, master, mistress, boss, supervisor, employer, landlord, owner, proprietor - qualities of a leader is a concern for the integrity and prosperity of the people, the land, the language and other cultural treasures (e.g. oratory and song poetry), and an aggressive and sustained response to outside forces that may threaten these.

**Tamariki:** Children.

**Taonga:** Treasures, anything considered to be of value.

**Te Ao Māori:** The Māori worldview.

**Tikanga:** Protocols, customary practices and principles.

**Tūpuna:** Ancestors, grandparents – western dialect variation of tūpuna.

**Waka:** Canoe.

**Waka ama:** Outrigger canoe.

**Whānau:** extended family, family group, a familiar term of address to a number of people – the primary economic unit of traditional Māori society.

**Whakapapa:** Genealogy.

**Whare whakairo:** Carved meeting house.