He Iwi Rū | Quake Nation: effective interactive data visualisation in the museum

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ABSTRACT: This paper looks at He Iwi Rū | Quake Nation, an interactive visualisation in the Museum of New Zealand Te Papa Tongarewa, as a case study for the practical application of interactive data visualisation in the museum space. It explores how the considerations that affect the concept and design development can impact the visitor, and vice versa (i.e. how considering the audiences can affect the exhibition development process); what the production, control and use of interactive data visualisations tell us about museum interpretation and the visitor as meaning maker; and how the general principles of museum and heritage interpretation apply to this particular example and medium. As just one part of the *Whakarūaumoko* | *Active Land* exhibition within the museum's Te Taiao | Nature exhibition zone, Quake Nation demonstrates that well-visualised data can be used not only to tell and reveal stories, but also to invite personal interaction.

KEYWORDS: Data visualisation, digital interactive, earthquakes, exhibitions, interpretation, meaning making, museum, Quake Nation, Museum of New Zealand Te Papa Tongarewa, Te Taiao | Nature.

Encountering He Iwi Rū | Quake Nation

Te Taiao | Nature is the long-term natural environment exhibition zone at the Museum of New Zealand Te Papa Tongarewa (Te Papa). It opened in 2019, replacing *Awesome Forces* and *Mountains to Sea* (which had remained largely unchanged since the museum opened in 1998), and weaves together science and mātauranga Māori in a uniquely Aotearoa New Zealand experience. At the far end of Te Taiao | Nature, in the *Whakarūaumoko* | *Active Land* exhibition and next to the popular Quake House, sits He Iwi Rū | Quake Nation, a bilingual, data-driven, interactive visualisation in the form of a large, tilted touchscreen (Fig. 1).

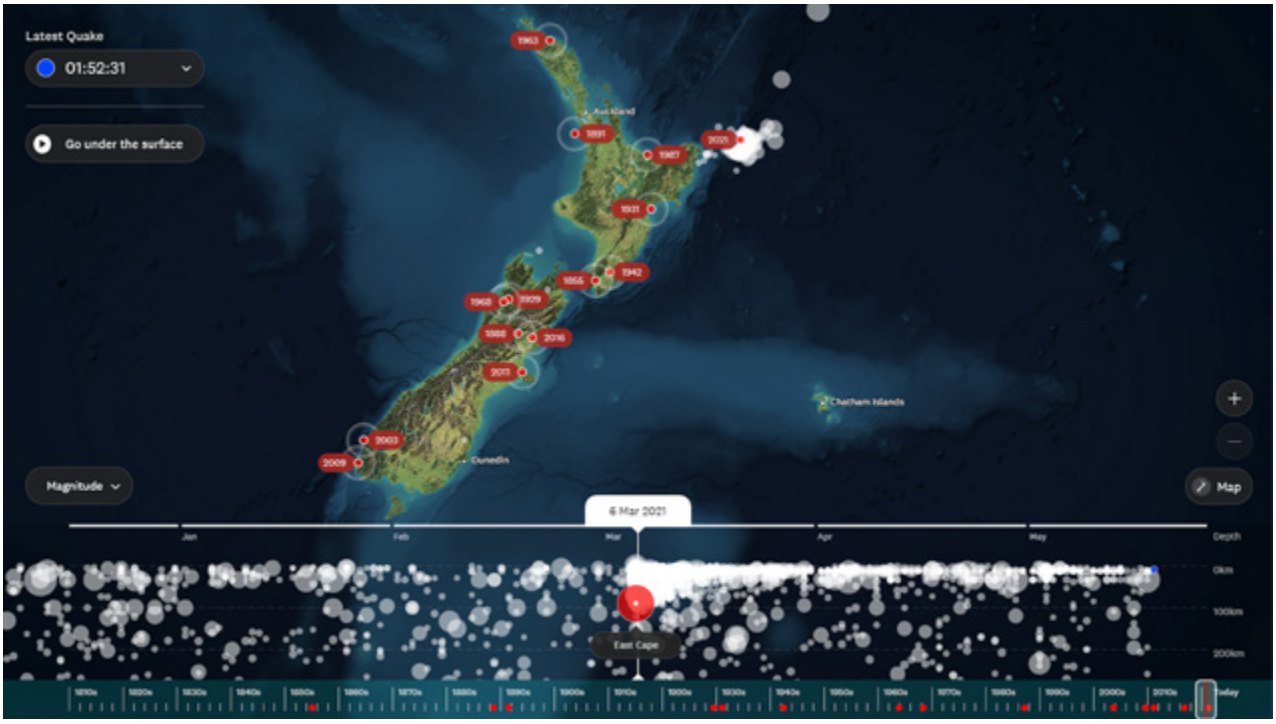

Fig. 1 Quake Nation (image courtesy of Robin Marshall, Te Papa).

Quake Nation invites visitors to explore every recorded earthquake greater than magnitude 3 in Aotearoa New Zealand. These number hundreds of thousands and date from 1815 to the present day – in fact, to the present *minute*, due to the direct feed of Application Programming Interface (API) data to the visualisation, courtesy of New Zealand's GeoNet project. A clock at the top right of the Quake Nation screen shows how many minutes have elapsed since the last quake. A large, zoomable topographical map of Aotearoa and the largely submerged continent of Zealandia are displayed, under which visitors can scroll through a timeline that charts quakes by depth and magnitude – making it navigable by place and time. White 'bubbles' of various sizes that denote quake magnitude flash (or 'bubble up') across the map as the timeline is scrolled. A dozen or so quakes of significance are permanently highlighted on the map. These can be selected to further explore the events, old and new, including photographs and news of quake damage, making the experience also navigable by story (Fig. 2).

A button above the timeline provides a key to the different magnitudes. By taking control of the timeline and map, visitors can create their own data experience. However, if the screen is left alone, the map and timeline automatically begin a temporal animation through the data (known as the screen's 'attractor state'), catching the attention of passers-by. The years and decades pass with increasing speed and the earthquakes 'pop' on-screen with greater frequency as the years become richer in data. Hypocentre data (from the subduction zone) is also revealed, by a fixed rotation of the flat map.[1] This displays the myriad hypocentres under the Earth's surface (the epicentre of an earthquake is the point on the Earth's surface directly above the hypocentre) and also reveals the boundary between the Pacific and Australian plates in three dimensions (Fig. 3).

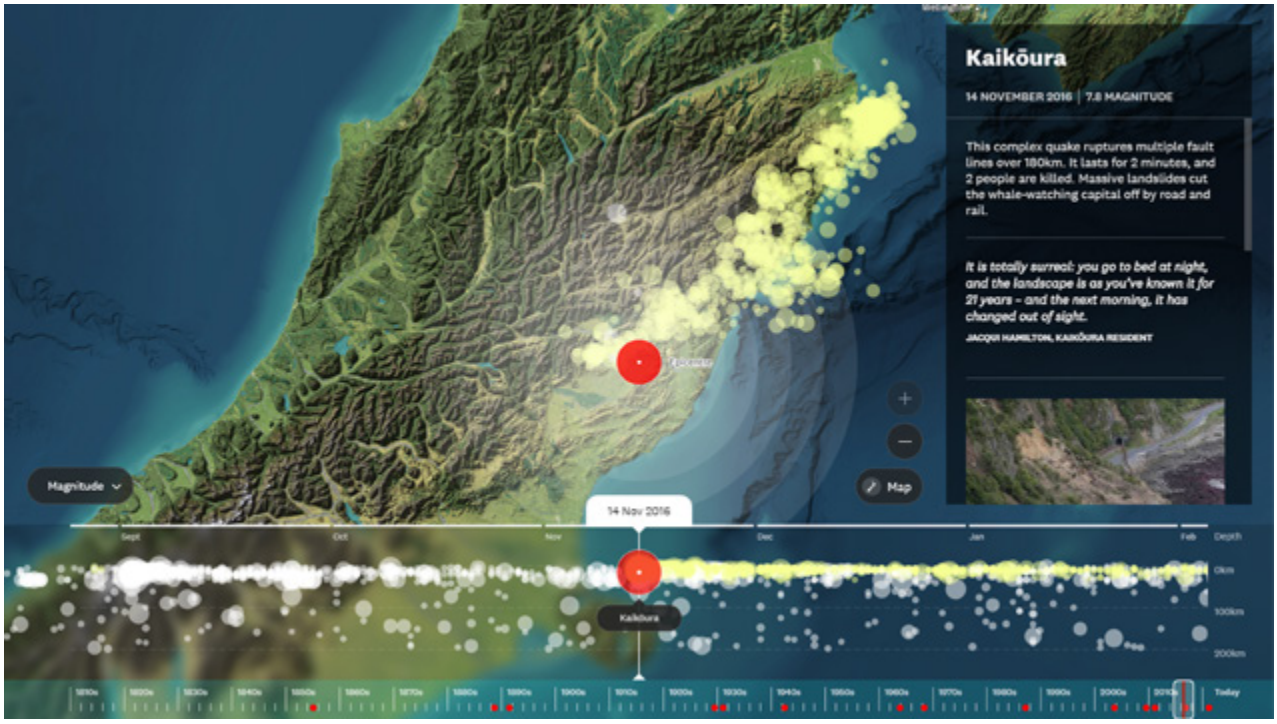

Fig. 2 Detail of the 2016 Kaikōura earthquake in Quake Nation (image courtesy of Robin Marshall, Te Papa).

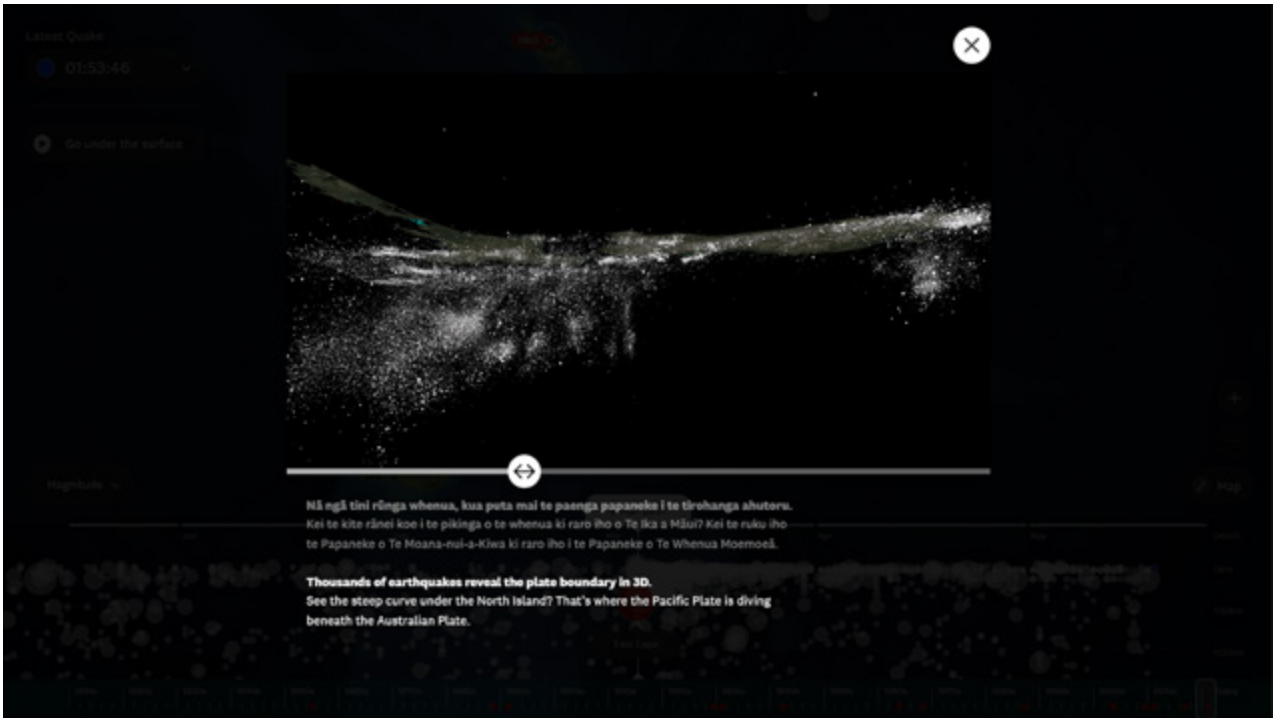

Fig. 3 Earthquake hypocentre data visualisation in Quake Nation (image courtesy of Robin Marshall, Te Papa).

Quake Nation is designed to do many things. For users, perhaps the most common discovery is that earthquakes are not one-off events, but spikes in a never-ending sequence of tremors. For the museum, one of the benefits of a digital interactive display is that it can be automatically refreshed and kept up to the minute, something only the digital medium can achieve. If print graphics were used to visualise the data, reprints would be needed to account for new events. The only printed graphic for Quake Nation is the minimal signage (Fig. 4).

The digital experience is a complement to other more physical components of the *Whakarūaumoko* | *Active Land* exhibition, including the Quake House, the Shake Table and the Tsunami Tank, as explained by Amos Mann, Digital Production Lead on Te Taiao | Nature: 'Quake Nation can deal with specifics *and* generalities, whereas those other experiences are much more effective at dealing with abstracted generalities, and less useful in dealing with concrete specifics, especially not specifics of what actually happened yesterday or in the past hour' (Mann 2020).[2]

This article looks at Quake Nation as a case study for the practical application of interactive data visualisation in the museum space. It explores how considerations during the concept, design and development process can impact the visitor, and vice versa (i.e. how considering the audiences can affect the exhibition development process of the digital interactive); what the production, control and use of interactive data visualisations tell us about museum interpretation and the visitor as meaning maker; and how the general principles of museum and heritage interpretation apply to this particular example and medium. I was able to learn about the production journey of Quake Nation from Amos Mann, who provided me with much insight and documentation.

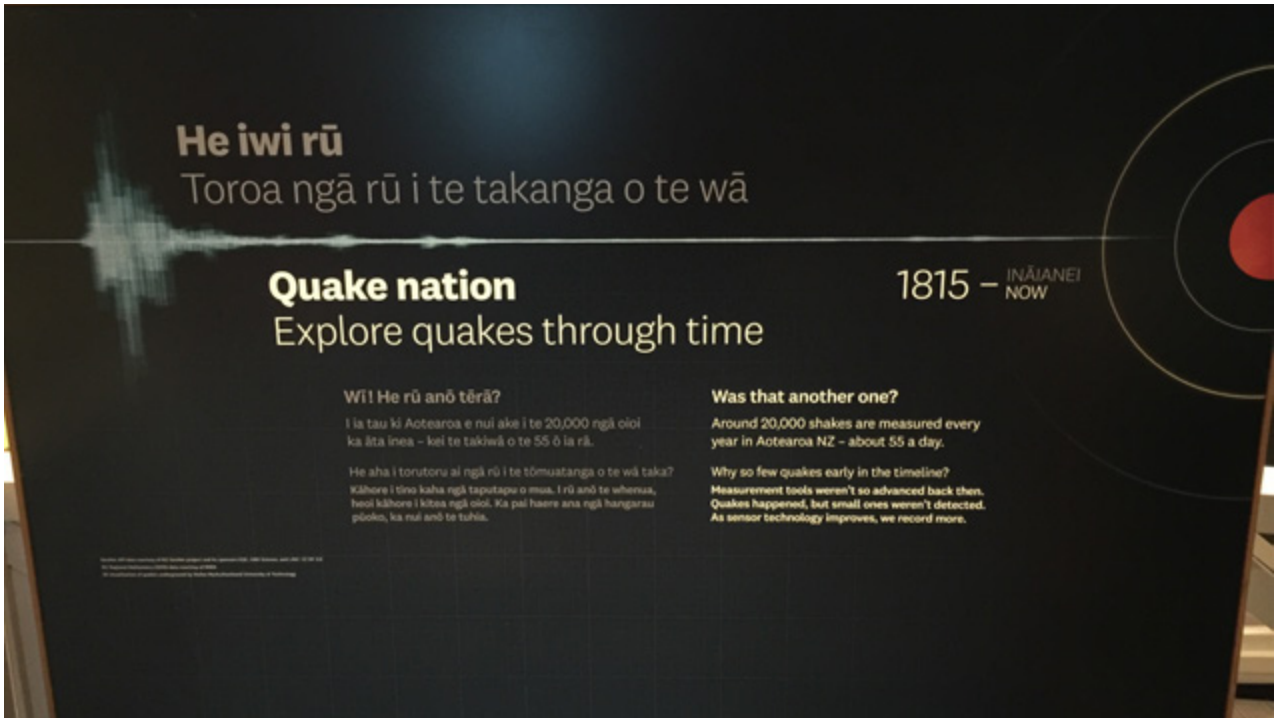

Fig. 4 Minimal interpretive signage above the Quake Nation display (photo: Michael Upchurch).

Visualising data

> Now we are overwhelmed with the amount of knowledge at our disposal and an exhibition-maker must reach beyond objects and labels to a more nuanced and complex sense of what is important to sustain public engagement. (Spock 2015: 382)

Data is increasingly used as a tool for heritage interpretation – when it is visualised, it can be used not only to tell and reveal stories, but also to invite personal interaction. Effective data visualisation need not be digital or even necessarily interactive – for example, cartography is one of the best examples of data visualisation, and maps visualise data effectively both on paper and in applications such as Google Maps. When combined with the 'open by default' approach to data adopted by the New Zealand government,[3] the opportunities for sharing data and telling stories increase even further.

Take as a recent example the Hard Data section of the Are We There Yet? exhibition at Tāmaki Paenga Hira Auckland War Memorial Museum, marking 125 years of women's suffrage in New Zealand (Fig. 5). The statistics Hard Data are visualised in such a way as to drive home various powerful gender issues, asking visitors to look at, and find themselves in, the numbers. As the exhibition website puts it, 'Data is power. The power to tell stories. The power to understand the world. Access to data can tell you about your place in the world, how you measure up, what's available to you and what's happening to you' (Tāmaki Paenga Hira Auckland War Memorial Museum n.d.)

Fig. 5 Visualising earnings data in the *Are We There Yet?* exhibition at Tāmaki Paenga Hira Auckland War Memorial Museum (photo: Lara Simmons).

But this also points to something else – the powerful and influential role of the interpreter in influencing the visitor by choosing what data to display and how to display it. With data visualisation, as with any representation of information, selectivity is central, even when data is generally viewed as being more objective than other types of information. As artist and designer Sey Min says, 'One thing we should remember when visualizing data is that biases can never be totally avoided, no matter how pure the original intention. Data, like the historical archive, is always partial and subject to the decisions that frame its collection' (Min 2015).

Designer Scott Murray makes a similar point, writing, 'Of course, visualizations, like words can be used to lie, mislead, or distort the truth. But when practiced honestly and with care, the process of visualization can help us see the world in a new way, revealing unexpected patterns and trends in the otherwise hidden information around us. At its best, data visualization is expert storytelling' (Murray 2013: 1).

With any emergent technology or tool that appears to enhance the museum experience, a healthy scepticism can also be appropriate (Spock 2015: 398). Te Papa staff planning the Quake Nation display asked themselves early on whether this was the only way to present the information, or whether there were more effective (including cost-effective) alternatives.

In museum spaces, the scepticism around digital media has tended to focus on the threat that screens might pose to the 'materiality' or authenticity of artefacts and on the risk of pursuing technology for its own sake (Henning 2006: 302–303). But data is not an object – certainly not in the traditional sense (although it may be an encoded representation). Unreadable in its raw form except through software, it requires some form of interpretation – organisation and display – to be coherent and understandable, in part (and especially with 'big data') due to its scale.[4] In what other format could audiences have access to details of every known earthquake greater than magnitude 3 in New Zealand?[5]

GNS Science, a Crown Research Institute, is one of Te Papa's founding partners and has a long-standing relationship with the museum, and in Quake Nation it provides the main dataset. However, Te Papa is able to supplement this with its own digital content in the form of historical and social stories. Other interactive data visualisations, whether in the exhibition space or online, can now directly incorporate digitised museum collections (digital heritage), such as Te Papa's Collections Online,[6] making more information available to visitors within the same context. The technical tools and theoretical approaches that make data visualisations

possible to achieve, in innovative, striking and often beautiful ways, have accelerated in recent years, and a separate essay could easily expand and expound on this particular interdisciplinary field. However, in the physical and online museum spaces, these tools and approaches can be seen as contributing to altering 'relationships between both visitors and communication technologies, and heritage sites and communication technologies' (Staiff 2016: 42). The growth of digital media has prompted museums and heritage places 'to go beyond the instructive authoritative voice … and more fully recognize how the new media brings a democratization that focuses less on the objects and places … and much more on the communities they serve' (Staiff 2016: 126).

The museologist Kerry Jimson observes: 'Good interpretation ensures that the subject is presented accurately and clearly and visitors are stimulated to explore, investigate, and question' (Jimson 2015: 534). Frith Williams, Head of Experience Design and Content at Te Papa, adds that good interpretation is presented in the most effective medium for the content, takes an involve/show-not-tell approach, takes into account the context and balance of the experience, and allows visitors to connect personally and emotionally (Frith Williams, pers. comm., 11 May 2021). Freeman Tilden's six principles of interpretation (1957) have been extended, expanded and critiqued in more recent years, yet still resonate (Jimson 2015). Quake Nation, as an example of contemporary interpretive practice, can be marked out as effectively abiding by Tilden's first four principles in particular:

1. Any interpretation that does not somehow relate what is being displayed or described to something within the personality or experience of the visitor will be sterile.
2. Information, as such, is not interpretation. Interpretation is revelation based upon information. But they are entirely different things. However, all interpretation includes information.
3. Interpretation is an art, which combines many arts, whether the materials presented are scientific, historical, or architectural. Any art is to some degree teachable.
4. The chief aim of interpretation is not instruction, but provocation.[7] (Tilden 1957)

At Te Papa, seven interpretive principles to guide the redevelopment of the whole Te Taiao | Nature exhibition zone were identified, based on the motivations and needs of target audiences:

1. Targeted – less is more.
2. Emotional – create 'sticky stories', change begins with connection.
3. Social – support collaboration.
4. Physical – make it playful (embodied learning).
5. Immersive – take them on a journey.
6. Empowering – hand over control, seeing yourself.
7. Real – real things, people, places, opportunities. (National Digital Forum 2019)

Williams stressed that the museum 'didn't start from medium (digital/analogue/face-to-face), because we shouldn't start there, but you will see where digital solutions were used *because* they supported those audience principles in ways that other media couldn't and added huge value'. In addition, the development of the wider exhibition was informed by the foundations of the museum's mission and renewal approach: 'INSPIRE' (see Appendix A). According to Williams, 'We set an overall renewal approach: the type of experience we were hoping to create in a nutshell, very much informed by technological, social and environmental trends. "Inspire wonder" recognises that in this digital age when information is available anywhere, any time by anyone, our role shifts towards being a place of inspiration' (National Digital Forum 2019).

Concept development

Te Papa realised early on that Quake Nation was no ordinary interpretation challenge and, according to Mann, the museum was 'looking more widely at the field of data visualisation, as part of a wider common capabilities programme to develop our thinking and skills and know-how in a number of areas of digital development' (Mann 2020).[8] Therefore, the museum set up two-day workshops with experts in a number of fields, including data visualisation.

One workshop was led by Chris McDowall,[9] who raised the key point that 'rich data storytelling can come from combining two or more datasets rather than presenting a single dataset by itself' (Mann 2020). The workshops

identified five primary design goals that the visualisation needed to achieve with the viewer, for them to come away from the interactive with the following knowledge/ experience:

1. Earthquakes are happening right now.
2. I heard from someone who was there.
3. I can see all the quakes over time and get a sense of significant quakes' place in the sequence (2D).
4. I can see all quakes over space.
5. I understand earthquakes happen at different depths and in strong patterns (3D).[10] (Mann 2020)

These goals exemplify the understanding, now implicit (especially in digital exhibition design), that 'the digital savvy visitor wants to be a creator of meaning as a well as a consumer of meaning' (Staiff 2016: 127).

McDowall also worked up a prototype for visualising GeoNet data and combining social history data, while providing notes and recommendations on feasibility and viability, as well as showing how he made the prototype.[11] One of the challenges was that initial sketches depicted nicely spaced quake events, but the reality was a messy swarm of quakes, punctuated by occasional extreme bursts (McDowall *in* Mann 2020). Andy Kirk, a data visualisation expert, has explained that 'Our ideas are not the raw material, the data is … An important discipline you have to show as a data visualisation designer is NOT to be servant to just pursuing your initial idea … Ultimately you need to be respectful to the shape, size and conversation emerging from your data. That is the true raw material' (Kirk, 2020).

GeoNet and GNS Science also contributed to the concept development process. One of the challenges was thinking about the way the data was already presented on GeoNet's publicly accessible (and popular) website and app, designed for individuals to use on their own personal devices, and presenting it in a different format for the exhibition.[12] Simply putting a computer in the exhibition space environment and running the GeoNet website would not achieve Te Papa's goals for visitor experience. What would be the points of difference for an exhibition-based earthquake experience? And what difference in value could Te Papa produce? The GeoNet website is excellently suited to its intended context of use, to its intended audiences and to its intended goals for audiences. For the same to be true of Quake Nation, it required a 'large-scale, more social and creative experience' (Mann 2020).

> The GeoNet website didn't focus so much on navigation of all of the data, instead focusing the user on lists to select individual data points from. Also, we were aware the GeoNet app is very popular and plays a key role in New Zealanders' relationship with earthquakes already, so with an interactive data visualisation we were trying to clearly define a point of difference, rather than compete with what visitors probably already have in their pocket. (Mann 2020)

The team explored a number of ideas around other potential datasets, including the number of tweets or 111 calls made in relation to earthquakes, or GeoNet's 'felt' reports. The former were seen as weaker options, because Te Papa felt that the result would be a data storytelling 'truism' – when there is a quake, people tweet about it or phone 111 (Mann 2020). Such reports would be unsurprising and provide somewhat limited visitor takeaways. Felt reports (collected information about the intensity of shaking that people experienced during an earthquake) had potential, but an automated visualisation of this would have taken a lot of work. Such reports are not linked to a specific quake event and they contain inconsistent information (Mann 2020). The concept with the strongest potential for responding to audience motivations and needs, especially around interpretive principles 2 (emotional), 6 (empowering) and 7 (real), was to combine GeoNet data with newspaper articles and their quotess. This was particularly apt, as researchers had used newspaper reports to fill in historical data points within the GeoNet dataset (Mann 2020).

Other challenges included questions around scale. The sizes of the circles used to indicate individual quakes were originally based on magnitude values, but earthquake magnitude is measured on a logarithmic scale: a magnitude 6 earthquake is 10 times larger than a magnitude 5 quake and 100 times larger than a magnitude 4 quake. Using a more accurate comparison between the relative sizes of different events therefore helped the large quakes stand out against the background of more numerous smaller events (McDowall *in* Mann 2020).

These various discussions are good examples of the way the exhibition development team, through conversations with those who have specialised knowledge of the subject, attempted to reinterpret difficult or complex ideas in a comprehensible way, acting as 'audience advocates' and 'voicing the very questions that visitors may ask, looking at the concept from their point of view' (Jimson 2015: 539, 545). Williams added that 'an advantage of interpretive

staff not being experts in the field is that they tend to bring the audience perspective to some degree anyway – where necessary, we confirm that perspective through testing or reference to other research' (Frith Williams, pers. comm., 11 May 2021).

The audience

> The interpreter needs to gauge the level of prior knowledge among the participants and their response to the concept, as well as to identify any risks or difficulties the exhibition may pose. (Jimson 2015: 537)

During the initial user experience (UX) design process, visitors were asked to paper-prototype – to choose from a range of features and functions or write their own on sticky notes, and from these come up with a set of features and functions for their own personal ideal earthquake interactive. This audience testing confirmed what the museum anticipated – that people were equally interested in data and human stories. The team then used this insight to begin the design of the Quake Nation display (Mann 2020).[13]

Past observational research at Te Papa had shown that digital kiosks were, on average, used by two to three visitors simultaneously. The limitations on simultaneous engagement have often been seen as a common drawback of touchscreens, but these observations showed that when such interactives were developed correctly and at the right scale, they became quite a social experience, and this needed to be acknowledged.

The museum referred to feedback from Te Papa hosts (visitor guides) about an interactive earthquake timeline kiosk that visitors had used in previous exhibitions to explore the GeoNet website. This was a simple touchscreen timeline with about 12 major historical quakes. Tapping a quake brought up images and a short story. Hosts' interview responses included: 'Every New Zealander has an earthquake story. Everyone is eager to share if they have their own story', 'People loved seeing when the most recent earthquake was. People really love seeing when the earthquake happened and comparing to their own experience. People could say, I was just in Kaikōura, they just had an earthquake', 'Visitors like hearing from someone who has been through it, it resonates' and 'Richter numbers don't really mean anything to people who don't often feel them' (Mann 2020).

At various points throughout the process, the concept and communication (or learning) objectives were firmed up. A 'request for quote' clarified what Te Papa now wanted from a digital developer: 'display a dynamic, large-scale visualisation of NZ historic earthquake data, integrate social history content, represent live earthquake data and allow for a rapid response to noteworthy seismic events' (Mann 2020). And communication objectives – what visitors would learn (i.e. what they would feel, think and do) were fleshed out, as discussed below.

Identifying target visitor groups and trying to understand visitor interests is part of the interpreter's function (Jimson 2015: 534). Te Papa's Audience Impact Model (AIM) (see Appendix B) and goals for the project were based on a combination of audience research, an initial stage of UX research, and the storytelling and science communication that Te Papa had identified from input from GNS and social scientists at Victoria University of Wellington. This resulted in a set of impact categories that was then used to select the 12 initial quake stories that represent those categories (Mann 2020). A key quote from wider visitor research for Te Taiao | Nature, 'The interactive parts … it's such an effective way to learn … being part of it makes it unforgettable' (National Digital Forum 2019), reflects a great expression of learning theory. Adrian Kingston, Head of Digital Channels at Te Papa, described AIM as a tool for setting, designing for and measuring goals for audiences' impact of experience. It combines quantitative and qualitative measurement, enabling more meaningful understanding and sharing of the stories of audience learning and subsequent action (Adrian Kingston, pers. comm., 7 April 2021). It is about what the exhibition team want visitors to take away, and thereby guides development and design. It is worth noting here that Te Papa does not normally use AIM for individual exhibition components, but rather for exhibitions as whole.

Te Papa thinks about its audiences not only in terms of their demographic characteristics, but also their psychographic characteristics – their motivations and values in relation to cultural experiences. The museum uses the Maurice Hargreaves McIntyre (MHM) Culture Segments model.[14] Audience segments can also be thought of as 'interpretive communities', which allow museum professionals to differentiate between various motivations and responses (Mason 2005: 206–207). From the MHM model's culture segments, Te Papa identified three as targets: Affirmation (seekers of 'edutainment'), Expression ('creative communicators and collaborators') and Stimulation (seekers of new experiences), with an emphasis on the Affirmation segment.[15] Affirmation visitors share with the other two segments a desire for fun, but they place greater emphasis on self-development and learning, for themselves and their children, and need a certain degree of reassurance that an experience will offer them that quality.

Fig. 6 A literal 'contact zone' (photo: Lachie Phillipson, Springload).

The interactive had the following goals:

Prioritised THINK goals (intellectual responses)

1. FREQUENCY: Earthquakes happen very regularly in NZ, even if we don't feel them. They've happened in the past, they are happening now, and will continue to happen in the future.
2. IMPACT: Major quakes have occurred throughout our history, and they've always affected people.
3. NATURE: Most NZ quakes are caused by plate boundary dynamics: The epicentre pattern of NZ quakes marks the plate boundary.

FEEL goals (emotional responses)

1. Fascination: 'I get the big picture'.
2. Empathy for people who have gone through these events.
3. Drama: See a quake series or major quake sequence like Christchurch, including aftershocks, play out in seconds.[16]

Tone

Exploratory, empowering and powerful – in terms of having the power to reveal things and make things happen, make sense of data to get the big picture. Every dot has a story: A sense that 'these are not just dots on a map, that every dot has a story'. (Mann 2020)

This approach helps illustrate Quake Nation, in many if not all elements of the exhibition, as a site not only of communication, but also one focused on of meaning making. Visitors are active participants, drawing on their own experiences, and the display is a literal 'contact zone' rather than solely a place of instruction and dissemination (Mason 2005) (Fig.6). In moving towards co-creation and empowerment, the MHM model's spectrum of audience engagement is a useful tool, and one Te Papa has used and will continue to use (Frith Williams, pers. comm., 11 May 2021).

It is well known that 'People tend to remember facts more accurately if they encounter them in a story rather than in a list' (Carey *in* Spock 2015: 386). The team therefore also developed a 'user journey', part of which was recognising the need for the 'attractor state' of Quake Nation, so that it would be engaging and meaningful before any interaction actually begins (Mann 2020). The user

journey also addressed all the different ways visitors might engage with Quake Nation, which related quite closely to the design goals that arose from the workshop on data visualisation capabilities. Features and attributes critical to the success of Quake Nation were communicated with software development firms:

- Meaningful and accessible at first glance
- Large-scale
- Dynamic
- A big, beautiful visualisation
- Draws you in and makes you want to interact with it
- Brings data together to form a whole. (Mann 2020)

Design development

Exhibition tradecraft, as museum consultant Dan Spock has written, is 'never merely assemblages of objects and labels, but a series of exercises in making choices about creative design' (Spock 2015: 380). While specific to Quake Nation, the learning goals were informed by, and fed into, the wider interpretation plan for the whole of Te Taiao | Nature. It is important to remember that each experience in the whole exhibition played different but ultimately complementary roles. Williams explained that other parts of the exhibition were specifically designed to offer more complete or in-depth visitor stories – in particular, the audiovisual of people talking about their experiences of the 2011 Christchurch earthquake, and the blackboard, where visitors can contribute their own stories. Quake Nation did not need to do everything, since it was never going to be isolated from the other elements – together, they contribute to the full experience (Frith Williams, pers. comm., 11 May 2021). Therefore, the developers of Quake Nation were conscious of the ongoing development of other elements within *Whakarūaumoko | Active Land* and Te Taiao | Nature. Interestingly, the periodic violent shakes of the Quake House right behind Quake Nation provide a powerful corresponding sensory element that can elevate the impact of the digital interactive. As Jimson (2015: 539) has observed, '[T]he growing exhibition concept becomes an everāncreasing series of feedback loops as the larger team becomes involved with the content and development.'[17]

The Te Papa team, led by Digital Producer Kate Whitley, worked with Springload on UX/user interface (UI) design, research and development.[18] Springload built on the museum's initial concept, design and audience research. Staff and visitors used design prototypes on paper over a full-scale mock-up of the screen that would eventually be installed. This tested several possibilities and challenges: should it use a time-wheel or a timeline? How many pixels wide is a year? How long is a day? How can we prevent quake stories from being quite separate to the data visualisation when the goal is to integrate stories *with* the data?[19] This UX testing helped feed into and improve the aforementioned AIM. It also helped inform the design of the signs and symbols needed for the data visualisation and the UI, reducing the risk that audiences would not understand the data visualisation (Mann 2020).

One of the most significant goals for the new system was its ability to be constantly updated, to respond to new earthquake events as they occurred and tell the impact stories of those quakes. Mann described this to me:

> We needed to get away from this being a static exhibition built and left alone for 10–15 years, and instead more towards an exhibition system that was designed for and included features and functions for continuous update. The earthquake data interactive is one of the things in the exhibition that is built for quick updates in rapid response to a major event, and it also draws live data into the exhibition, via the GNS API. (Mann 2020)

The visitors who engaged with Quake Nation in 2020 will have had different experiences from those engaging with it in 2021 and beyond. There will be newer earthquake events to interact with, keeping the interactive display immediate and relevant to each new visitor.

The requirement for a social history/qualitative data aspect of the visualisation – the stories of individual quakes – prompted suggestions within the Te Papa team for what should be included and displayed:

- Connect and integrate social history impact story (including image(s) and video) with the quantitative data visualisation/representation of a significant event
- Use the different ways quake impact is quantified to differentiate stories from each other (impact on: property, land, lives, psychology, etc.)
- Major quake stories might appear and/or be accessed from points in the timeline, from

points on the map, and/or from 'story buttons', in ways that more fully integrate social history data with seismic data (we feel that integration of these types of data is a strong point of difference for this experience)

- Use social history data content to bring seismic data 'to life', creating a sense that 'every dot has a story'. (Mann 2020)

It is also worth noting that Springload built Quake Nation on Te Papa's Te Papahiko platform and design language system, technologies that enabled a user experience consistent with Te Papa's growing number of digital interactives (Springload n.d.).

Given the social experience observed earlier with the digital kiosks and the fact that 80% of Te Papa's audience is classed as 'social' (as opposed to 'solo') (National Digital Forum 2019), Quake Nation was designed to allow several users to make multiple touch gestures at the same time (Fig. 7).

Physical access is another key interpretive consideration for designers, as highlighted by Jimson (2015: 542):

> The final user interface was designed to be fully accessible. Text and interactive elements use contrasting colours to make the information easier to see by people with colour blindness or visual impairment. The ßscreen's height and viewing angle are designed for kids, and people who might be interacting with it from a wheelchair or mobility scooter. Quake Nation meets NZ Government Web Accessibility Standards and is bilingual in te reo Māori and English. (Springload n.d.)

Fig. 7 A social experience (photo: Lachie Phillipson, Springload).

'Ensuring that disabled visitors' needs are met is also part of an interpreter's work.' Just as a label needs to be legible, the same considerations go into interactive displays:

Research into how visitors are likely to move around a space (physical or digital), and how much information they can be expected to digest in that context, helps interpreters draw visitor attention to specific content. This is common to all good exhibition design. But while construction of meaning begins with the museum, it ends with the multiple ways in which visitors interact with the experience and the ideas they take from it. The museum essentially builds the parameters of a sandbox for the visitor to play in, while doing its utmost to ensure that play yields constructive results, as seen through the planning illustrated here. The responsibility for choice/selection is passed from the author to the user, but it never represents a full abdication of responsibility on the part of the authors/curators (Henning 2006: 311).

Post-opening responses and conclusions

The long-awaited exhibition opened in May 2019. The development of the interactive followed best practice by including a post-opening phase for monitoring visitor use and identifying and implementing improvements.[20] Analytics collected from the interactive, which involved logging every interaction to make the visitor experience more measurable, along with observing what visitors were trying to do and the problems they encountered, led to further adaptations and improvements.[21]

Mann was responsible for analysing the interactive's initial use by the public: 'In our observational research of visitor use of the interactive, we observed that of the visitors who came within proximity of Quake Nation, over 40% engage. This is an excellent conversion rate for a touchscreen interactive in an exhibition of this kind' (Mann *in* Springload n.d.) On average, two or more visitors interacted with Quake Nation each session, generally lasting over two minutes – a level of engagement that suggests people are using the exhibit for the purpose it was designed – to deepen their knowledge of New Zealand's earthquakes in a learning experience shared with others (Springload n.d.).

Engagement with the earthquake event stories was lower than expected, based on the emphasis the stories had in the

design. Only about 30% of people who viewed earthquake event information scrolled to the end of the content. This meant that users were engaged more with the high-level data visualisation and navigation tools, rather than specific events (Mann 2020).[22] With such a small percentage of users diving into the human stories, visitors may not be experiencing an empathic response to the degree intended for the interactive, or not experiencing it as much as they might be grasping the THINK goals (intellectual responses) around earthquake frequency and nature. However, Mann noted:

> What we observe is that many visitors are making empathic connections and understanding with the data presented in the visualisation, without the need to dive deeply into the story content. I would say this is a success of the presentation of the data – visualised in a way that is open enough for visitors to connect and 'inject' their own perspectives and experiences and empathetic awareness to their experience of and interaction with the data; yet designed and structured enough as to be meaningful. (Amos Mann, pers. comm., 12 May 2021)

As mentioned earlier, the experience is also about the whole rather than the parts – other exhibition components were designed much more strongly around visitor empathy. Specifically, those in the next segment in the visitor path of the exhibition (including the Christchurch earthquake audiovisual, the artworks created as a response to the 2011 Christchurch earthquake, the photo-montage walls and the blackboard) deal with earthquake impact specifically, rather than earthquake mechanics. which is where Quake Nation appears.

Quake Nation is not available online, because it has been purpose-built for the exhibition context, where it is best experienced on a large touchscreen, and because of budget constraints. In addition, GeoNet already hosts much of the data online, where it serves a more defined purpose as a vital source of reliable, accurate information for government agencies and the wider community (Mann 2020). Nor is Quake Nation designed for sharing on social media – again, because it is intended for a large screen (the brightness of which limits photography), because GeoNet already supports sharing similar data and because other parts of Te Taiao | Nature are more suited to that purpose. That said, Te Papa would welcome opportunities to install Quake Nation in other centres around New Zealand, with the aim of reaching people beyond the museum walls, in line with the 'Reach out' principle of Te Taiao | Nature (see Appendix A).

Graham Black has written about how museum practice in the twenty-first century is developing towards both traditional and new audiences, emphasising that there is not a choice to be made between the two – museums need both (Black 2015: 123). Te Papa did not make explicit the role that Quake Nation plays in attracting *new* audiences. However, Te Taiao | Nature as a whole was intended to both increase visits by existing audiences and attract new ones. Research a few months after the exhibition zone opened showed some success – for example, significant increases in visits by local visitors, millennials and families (Frith Williams, pers. comm., 11 May 2021).

It is worth reflecting on the extent to which the visitor even realises they are playing with a dataset. Indeed, should they be aware of this? In a talk in 2020, McDowall explained the aims of his data visualisation book *We Are Here: An Atlas of Aotearoa* (2019): 'It was a really deliberate decision not to use this term "data". And for older people as well, I think it's quite a distancing term; it's quite a cold word, and I don't know if it's so helpful. And the data's not the point; the point is the insights you get from it or the things that you see' (Radio New Zealand 2020). When he had asked younger people what they thought about data, the frequent response was 'Oh, you mean like on my phone?'

A testament to Quake Nation's effectiveness was the Best Map Design award presented to Springload at the 2019 New Zealand Spatial Excellence Awards, for 'showing people how maps can be used to tell complex scientific stories and educate the public' (New Zealand Spatial Excellence Awards n.d.). But perhaps the most telling analysis comes from a summary of overheard visitor responses – in this case, two people in their 30s and a four-year-old:

> These are the earthquakes we've been having … Now this one was 1931. My grandad was there … Edgecombe, 6.5! … Oh, Wairarapa … Look, big earthquake in Christchurch, that's where Jack lives. It knocked down lots of buildings, the earth just shook and shook … Do you want to go into the [earthquake] house to see what an earthquake feels like? It's okay if that's too scary. (Mann 2020)

In this active and engaged exchange, there is clearly resonance and wonder, some learning, connection to the land, to place, to shared histories and to one another, and curiosity to discover more.

It is important that Te Taiao | Nature visitors do not, as Luigina Ciolfi, a specialist in human–computer interaction in museums, describes, 'perceive a gap between the physical, material experience of the exhibition and the digital interaction available'. Instead, the exhibition design should provide 'elements as a bridge between an exhibit and the multimedia content [which] sustains the visitor's embodied and emplaced engagement' (Ciolfi 2015: 441). The *Whakarūaumoko* | *Active Land* exhibition achieves this through the well-conceived placement of different but complementary experiences to engage audiences in multiple ways, as evidenced by the visitors quoted above. In this regard, then, Quake Nation serves as a useful illustration of Te Papa as both temple (a place of contemplation or wonder) and forum (a place for negotiation and experimentation) (McLean 2004).

On the whole, the final Quake nation interactive display reflects the INSPIRE renewal approach and interpretive principles of Te Taiao | Nature (see Appendix A). As mentioned above, given the complexity of the overall exhibition and its use of different elements, the intention was not necessarily for every individual exhibit or object to fulfil every principle and goal. It would have been difficult (and arguably unwise or inappropriate if appearing forced) to focus too much on nurturing diversity and to incorporate mātauranga Māori.

The rigorous concept and design development process detailed in this article provides a useful reference for evaluating success in the future. It may be too soon for the museum to perform a detailed assessment. Te Papa is unable to measure/monitor visitor behaviour for every component against the specific feel, think, do/do next goals discussed (see 'The audience' above). The museum has planned new research for some high-investment components, such as The Current, but there is no budget available to evaluate everything. Visitor numbers (even during tumultuous 2020) and the general responses to Te Taiao | Nature have been positive, negating the need for an autopsy. If or how the museum addresses any perceived shortcomings of the interactive has yet to be seen. Nevertheless, the touchscreen continues to evolve.

On 5 March 2021, a number of large offshore earthquakes triggered tsunami warnings for much of the coastline of Aotearoa. Many thousands of people evacuated coastal regions. In the days following, visitors were observed using Quake Nation to search for the relevant epicentres. In quick response, Te Papa added a new story to the interactive – the story of those noteworthy warnings and evacuations – further aiding and promoting discussion among visitors, and allowing them to remember and understand that we truly do live in a quake nation (Figs 8 and 9). The next time you experience a shake, Te Taiao | Nature – Quake Nation will already be telling the story.

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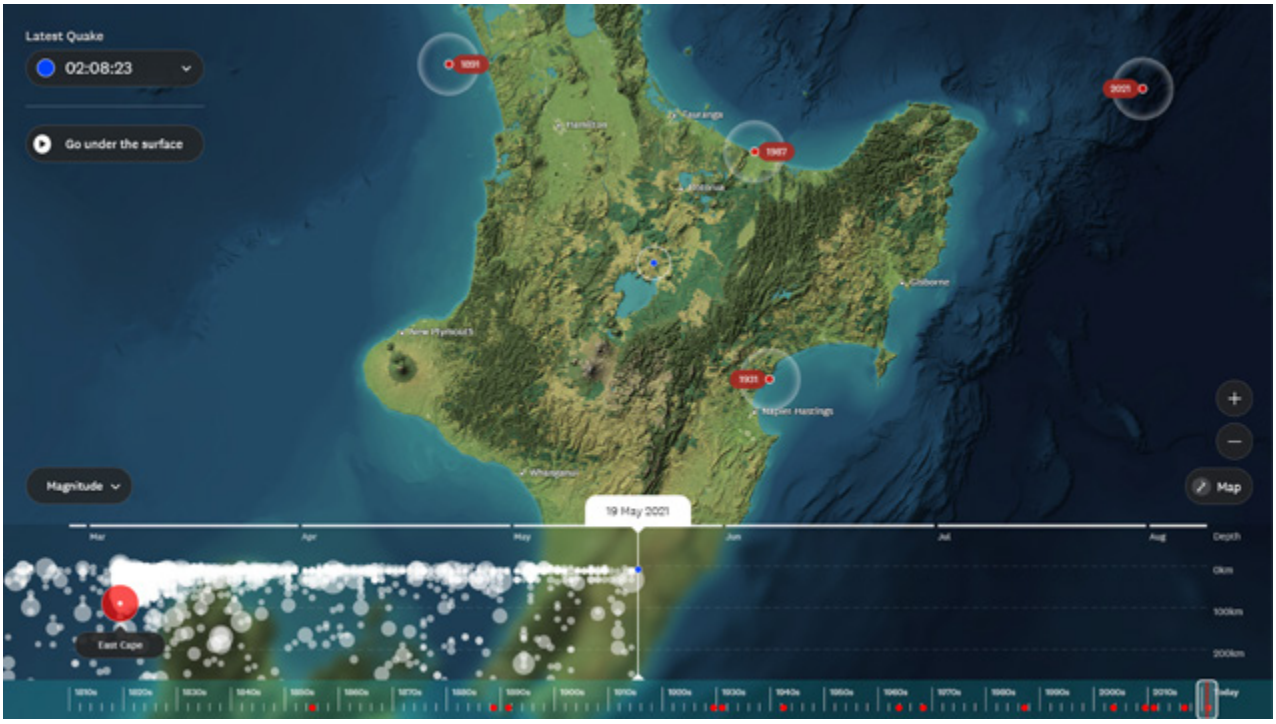

Fig. 8 Quake Nation, showing the new story marker for 5 March 2021 (image courtesy of Robin Marshall, Te Papa).

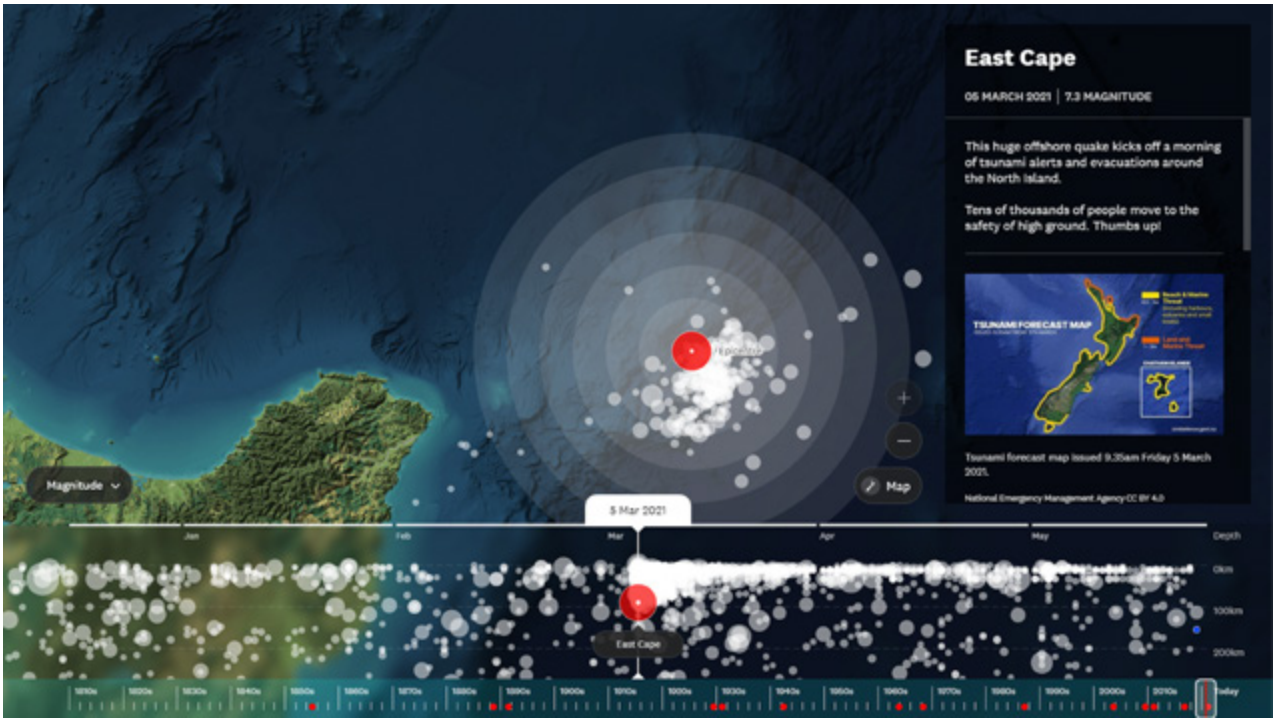

Fig. 9 Responding to the latest data (image courtesy of Robin Marshall, Te Papa).

Notes

1 New Zealand regional bathymetry data (or hypocentre data) was provided courtesy of the National Institute of Water and Atmospheric Research, and the three-dimensional visualisation of underground quakes by Stefan Marks at Auckland University of Technology.

2 With Te Papa's permission, Amos Mann, Digital Production Lead on Te Taiao | Nature, provided me with several unpublished, draft or untitled internal Te Papa documents relating to the development of Quake Nation. These were provided as email attachments, along with some email correspondence, on 18 and 27 August and 2 September 2020, and are cited in this paper as 'Mann (2020)' or '[Author (if known)] *in* Mann (2020)'. I am grateful to all of the staff and individuals from other organisations who contributed to these documents, which were an invaluable resource for understanding the considerations inherent in producing the interactive display.

3 See https://www.data.govt.nz/toolkit/policies/open-data-policy

4 Michelle Henning makes the interesting point that 'Numerical representation makes it possible to store enormous amounts of data and digitized media, something that makes new media museum-like' (Henning 2006: 307).

5 As with many large datasets, cleaning up the data is often necessary to remove anything irrelevant. In this case, all quakes that registered below magnitude 3 were removed.

6 See https://collections.tepapa.govt.nz

7 Te Papa would use the word 'inspiration' in addition to 'provocation'.

8 The idea was to identify digital tools/solutions that Te Papa could foresee using regularly in the future (as opposed to bespoke options) and might therefore invest in, with that continued use in mind (e.g. digital labels).

9 Chris McDowall is an Auckland-based geographer who creates maps and data visualisations, and is the co-creator of *We Are Here, An Atlas of Aotearoa*, Auckland: Massey University Press, 2019.

10 This workshop was Te Papa's first go at prioritising goals, recognising that, for example, it might not be possible to include number 5 in the scope of the project.

11 Chris McDowall also strongly recommended that anyone seeking to understand the visualisation design process should read Kirk (2015).

12 See https://www.geonet.org.nz/earthquake

13 Te Papa UX Designer Karen Bryce, Te Papa UX Researcher Kate Wainless and Te Papa Digital Producer Jean-Marie O'Donnell designed and conducted UX research with visitors at Te Papa.

14 These culture segments are personas developed specifically for the arts and cultural sector, and are used by museums internationally – see https://mhminsight.com/culture-segments

15 The Expression and Stimulation segments are also Te Papa's largest culture segments, at 32% and 17%, respectively, and much of the exhibition focused on them. The Affirmation segment accounts for 12% (National Digital Forum 2019).

16 However, it was recognised that more in-depth stories about human impact would be covered in other areas of the exhibition, keeping the human impact represented in the Quake Nation interactive lighter, through images or quotes (Mann 2020).

17 This approach to the production process differs significantly from that in book publishing, where reader feedback during the production phase is usually minimal in comparison. A notable exception here was with the aforementioned *We Are Here*, where Chris McDowall and Tim Denee constantly looped prototypes of their data visualisations and their designs past test subjects to challenge what they assumed might work and be understood. This owed much to the format of the book, where stories are told primarily through the visualisations – more so than words.

18 Springload is an independent Wellington-based digital agency.

19 For more about Springload's work on the interactive, see Springload (n.d.).

20 Approximately 15% of the budget remained for this part of the project (Mann 2020).

21 An example of an improvement was making the entire timeline visible along the bottom, so that the interactive would not rest on a data-poor section and all the data can be seen at once, and to make it easier to scroll through all years, so you can skip effortlessly from 2019 to 1819, for example (Springload n.d.).

22 This was an issue that could not be improved with the remaining budget and would have required a greater rethink (Mann 2020).

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Appendix A: Te Taiao | Nature – foundations

The development of the Te Taiao | Nature exhibition zone was informed by the foundations of the museum's mission and renewal approach: 'INSPIRE'. The information below is taken from a slide presented during the talk *Frith Williams: Te Taiao | Nature: Guiding principles* (National Digital Forum 2019).

Foundations

MISSION – Changing hearts, minds, lives

Renewal approach –

Inspire wonder [inspiration over information]

Nurture diversity [biculturalism, multiple perspectives]

Shake things up [tackling tricky topics]

Prepare for the future [sustainable, inclusive society]

Invite involvement [partnerships, play, creativity, debate]

Reach out [to onsite, offsite, online audiences]

Empower our communities [mana taonga]

Appendix B: Draft Te Papa Audience Impact Model for Quake Nation

Te Papa uses this five-step model as a structure for storytelling. The impacts cover attention > response > connection > learning > action. The museum doesn't normally use its Audience Impact Model (AIM) for individual exhibition components, but rather for exhibitions as a whole. This AIM is an incomplete draft and doesn't necessarily distinguish between aspects that represent 'what some visitors might happen to do' and aspects that 'are designed/intended for them to do' (represented by feel, think, do/do next goals).

1	2	3	4	5
Attention caught	**Immediate response**	**Personal connection**	**Simple learning**	**Contextual learning**
Drawn to the interactive by its look and feel Attractor loop/or imagery/(on slave screen) Title/first text seen Noticed interactive	'Nice map of NZ' Like the colours/design Glance and get it Understand frequency: 'I didn't know there were so many earthquakes'	'I've been to Napier/ CHCH/Kaikōura and I recognise it' My own personal earthquake story	'Wow, lots of earthquakes were going on around me all the time' 'GNS measures 50–80 earthquakes every day' 'The Canterbury quakes were not one event but hundreds' 'Earthquakes have always happened here' 'Quakes have been destructive throughout our history'	'If a quake could happen at any time, am I prepared?' 'It's not a question of if but when the next quake happens' 'Could it happen where I live?' 'Ah, so that's how the dots join up' [fault lines] 'If they've always happened, they'll happen again, maybe near me' 'I didn't realise the fault line ran through my town'

6	7	8	9	10
Applied personal learning	**Applied empathetic learning**	**Personal action**	**Group/ community impact**	**National impact**
Understood the threat posed by quakes and that they may affect me too Helped my children feel OK about quakes and not scared – demystifying them	I feel more empathy for people who have been through quakes			