ENABLING DESIGN PARTNERSHIPS THROUGH PARAMETRIC DESIGN VISUALISATION

A case study of visual communication techniques implemented on an infrastructure design project where partnership with indigenous communities was integral to success.

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Abstract. Where there is a commitment authentically engage indigenous communities in the design decision process, the relationships and communication methods that are used are an integral part of the design project. In an Aotearoa New Zealand context, mana whenua (the name given to the local indigenous group with historical rights to the land) are engaged at various levels with the Crown on infrastructure projects to achieve mutually beneficial outcomes in alignment with Te Tiriti o Waitangi. Infrastructure projects are communicated using specialist language and drawings, which is often unfamiliar to non-professionals. This is a learning opportunity for non-professional stakeholders and a pre-requisite to holistically understand and therefore meaningfully contribute to a project. This paper describes a case study of the evolving application of computational design as an additive communication technique for consultation sessions with mana whenua. This paper compares 2D documentation, pre-rendered 3D models, and interactive parametric modelling approaches. A major insight gained through this comparison of approaches was that enabling mana whenua to fully engage with a 3D model through interactive parametric modelling was effective in deepening understanding of the project. This deeper understanding of the project and its context could enable them to utilise their tacit knowledge of the land to make important contributions crucial to the project and ensure the project is in alignment with mana whenua values and aspirations.

Keywords. Parametric design visualisation, design collaboration, computational design, parametric modelling, co-design, infrastructure design engagement, model federation, mana whenua.

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1. Introduction

Where there is an authentic commitment to engage indigenous communities in the design decision-making process, relationship building and communication are an integral part of the design project. This paper represents a best attempt to navigate this relationship and its context mindfully and practically, with an acknowledgement that there is still plenty to learn and recognising that mana whenua groups across Aotearoa New Zealand are unique in their identities, histories, approaches, and worldviews. This paper describes a case study of an application of computational design as a communication technique for integrated design consultation sessions, specifically in the context of Aotearoa New Zealand indigenous communities.

In many countries, indigenous communities are being engaged more often in discussions and decisions that affect their wellbeing and ancestral lands. Government departments have established dedicated portfolios to foster relationships between indigenous communities and the Crown such as New Zealand's *Te Arawhiti*, the Office for Māori Crown Relationships, and Australia's National Indigenous Australians Agency (Te Arawhiti, 2023a; National Indigenous Australians Agency, 2023). In Aotearoa New Zealand, *mana whenua* are Māori indigenous people who have power, rights, and authority over land (Waka Kotahi NZ Transport Agency, 2023). As a result of *Te Tiriti o Waitangi* (known in English as the Treaty of Waitangi) the New Zealand government has a responsibility to partner with Māori whilst upholding Te Tiriti o Waitangi principles of partnership, protection and participation. In the context of infrastructure projects, the approach to partnership to achieve mutually beneficial outcomes with mana whenua is often set out in a framework, for example *Hononga ki te iwi* (Our Māori Engagement Framework) created by Waka Kotahi NZ Transport Agency (2023). Whilst these frameworks provide a guideline, it should again be noted that mana whenua engagement is not homogenous and the agreed approach to design success will be best achieved through connection and understanding of desired outcomes.

Building on existing engagement frameworks, improved design outcomes for mana whenua could be achieved from improved communication of design projects' visual, environmental, social, economic, and cultural impacts. This enables a more engaging design feedback and participation stage. The use of specialist drawings such as plans and sections is unfamiliar to many non-technical stakeholders (Bates-Brkljac, 2008), and presents a learning opportunity on infrastructure projects. As 3D parametric modelling software becomes more present within design practices, there is an opportunity to make design representations more accessible to non-professionals.

The case study in this paper describes the design communication approaches used on an ongoing project located in a geographical area of high significance to mana whenua. It discusses the novel use of using computational design as a tool to enable informed decision-making and meaningful stakeholder engagement within a design context. The use of parametric modelling as a method to visualise and rapidly iterate on design elements became an integral part of the project's multidisciplinary programme of works. This method meant the design team and mana whenua could be efficient with their time and keep on top of changes as the rest of the project developed.

2. Methodology

This paper is the formalisation of a reflection-on-action process, as defined in Schön's *Reflective Practitioner: How professionals think in action* (1983) conducted to solidify learnings from a novel application of computational design to involve non-technical partners in the design process, with the aim of improving future design processes. Findings can be applied not only to design work similar to the case study, but also to any design project involving non-technical participants.

Throughout the design process, designers draw on tacit knowledge to intuitively make process on the design problem. This case study reflects on the use of digital tools to bring non-technical design partners into this process and enable them to draw on their lived experiences and be a genuine part of the design process.

3. Engagement With Mana Whenua

Te Arawhiti has developed a range of mana whenua engagement guidelines that define what a genuine engagement process is from a Māori perspective.

> "For Māori, the process of genuine engagement with Māori by the government is:
>
> - an acknowledgement of their rangatiratanga (right to exercise authority) and status as Treaty partners
> - an acknowledgement that mātauranga Māori (Māori knowledge and understanding) makes an important contribution to solving policy and practical problems
> - an acknowledgement that Māori have the resources and capability to contribute; and
> - an acknowledgement that some issues affect Māori disproportionately and are therefore better placed to develop the solutions (Te Arawhiti, 2023b, p.2)."

Te Arawhiti defines a spectrum of levels of engagement based on the significance of the issue and how much impact the project may have on Māori interests. Whilst this offers a general guideline, each engagement will be distinctive, emphasising the critical need for all parties to recognise that engaging with Māori and mana whenua is not a 'one-size-fits-all' endeavour. This spectrum is referenced in the engagement framework of large government departments such as Waka Kotahi NZ Transport Agency (2023) For design firms, this means building relationships with local *iwi* (tribes) and *hapū* (subtribes) to determine the extent of impact on them and involving them to varying extents from informing them up to working with them as co-designers (Waka Kotahi NZ Transport Agency, 2023). Overall, the core of these guidelines is "early, inclusive and broad" engagement (Te Arawhiti, 2023b, p.2).

A case study by The Auckland Co-Design Lab (2023) highlights their learnings based on critical reflection and feedback. In this case study, the authors discuss the co-design process that was facilitated between Whānau Āwhina Plunket and local *tamariki* (children) and their *whānau* (families) on a redesign of a community family centre, now named Poutokomanawa. The Auckland Co-Design Lab's case study defines five main principles of the co-design process, one of which was Tino Rangatiratanga -

> "Whānau have the autonomy to decide how and when they will participate, as well as decision making opportunities within the process (Auckland Co-Design Lab, 2023, p.12)."

The key learnings the authors provide include the finding that the overall perception of the experience of the building and its services is significantly impacted by the way whānau feel in the space (Auckland Co-Design Lab, 2023).

The positive outcomes found in the Poutokomanawa case study are important to learn from, and based on these learnings projects should provide the broadest possible description of the project so that they can enable mana whenua to decide where opportunities are. This is a space where 3D digital tools and computational design could enable decision making by providing a fuller picture of the design space. Again, each engagement will be different, and it is important to listen to the people you are working with, as they are best placed to determine where they should contribute.

4. Visual Representation in Co-Design

Participatory design, often used interchangeably with co-design, is generally defined as design where stakeholders are participants in the cooperative making or adjusting of artefacts, systems, or technologies (Bannon and Ehn, 2012). Co-design methods in the AEC industry come in many forms from sketching and pointing to printed plans, to more technology-driven interactive approaches like geospatial platforms, augmented reality, or virtual reality (Dembski et al., 2019).

Visual representation of the project is highly influential to the way it is perceived by the participant. It is important for stakeholders and experts to understand the project and its wider context to make meaningful contributions. Sometimes there is not enough context in the visual representation of a project; for example, in specialist engineering and architecture documentation, symbols representing underground utilities can be understood by designers but not necessarily non-professionals. This means that the perception formed by a non-professional of the project is incomplete and may lead to misunderstandings. On the other hand, authors of visual representations often exacerbate misunderstandings by embellishing models to portray the effects of the finished project in context (Bates-Brkljac, 2008). However, they must consider how this representation is influencing participants' perception of the project and must avoid misrepresentation and consequently disappointment and distrust from the community.

The Auckland Design Manual recognises this when doing landscape and visual impact assessments by stating that:

> "Photographs should be provided from key and representative viewpoints to assist an evaluation of the visual effects." and that "For complex and/or sensitive proposals it may be of assistance to prepare photomontages or visual simulations from key and representative viewpoints to assist an evaluation of the visual effects (Auckland City Council, 2017, p.8)."

It is not enough to just view design options in comparison to one another, or in isolation, relying on all parties understanding the communication style of engineering drawings. They need to be presented, geometrically or otherwise, in a wider context.

5. Case Study: Evolving Approaches to the Modelling of Pou Whenua

Our ongoing case study project involves a broad range of people of varying technical expertise, from various engineering and technical consultants to mana whenua and the client. The technical nature of typical representation of engineering projects, and a recognition of the spectrum of perspectives involved meant that we needed to find an efficient, effective way to communicate that would be accessible to all (Bates-Brkljac, 2008).

For this project, one of the major co-design components was the refinement of locations for the *pou whenua* – a vertical artwork, anchored to the ground. Pou whenua communicate a range of things, from marking places of significance, acknowledging history, marking territory, or telling stories (University of Auckland, 2023; Walker, 2005). In the context of our case study, located in an area of significance to mana whenua, it was important to enable mana whenua to choose where they wanted to situate their pou whenua while maintaining sovereignty of their *mātauranga Māori* (Māori knowledge) they were comfortable with.

The design team were located in multiple offices across New Zealand, so design collaboration took place online primarily through online *hui* (gatherings) and emails. This segment will discuss the methods used throughout the hui and to determine the locations of pou whenua. Three collaboration approaches were iteratively developed over the course of the project: 2D documentation, pre-rendered 3D models, and interactive parametric modelling.

5.1. APPROACH 1 - TWO-DIMENSIONAL DOCUMENTATION

Before each hui, planning sessions were held by the design team to decide on a range of predefined potential locations for the pou whenua, avoiding locations where engineering constraints meant that construction would not be feasible. We considered potential clashes with utilities and other infrastructure, ease of maintenance access, and ease of construction access.

The goal at this stage of the project was to make broad decisions on locations and to build on our existing relationship with mana whenua. Due to the broad nature of the work, the design team worked with visual documentation that was readily available at that stage of the project - 2D geospatial documentation of the project used for planting arrangements and set-out of infrastructure elements. These drawings had reference layers documenting surrounding context with aerial imagery and overlays of significant ecological areas. On top of the existing documentation, we identified elements that may be of interest to mana whenua such as *wai* (water) and *wāhi tapu,* (sacred places) (Auckland Council, 2023) and highlighted them as a coloured overlay.

During the hui the engagement team discussed with each iwi where they might like to focus their efforts. During discussion, where data in the 2D documentation wasn't sufficient, participants referred to publicly available geospatial maps to situate the workshop members in site context and understand scale and existing features. After a discussion over the presented drawings, candidate locations were marked on the plans with a dot.

Presenting design plan drawings meant that the design team could easily talk about the locations, as they can understand the notation used in drawings, for example, lines

that represent drainage, kerbs, bridge foundations and other features. However, due to the scale and complexity of this project, it was easy for non- experts to become disoriented by the drawings, even if they were familiar with drawing notation (Rahmann and Walliss, 2014).

While the information the design team presented was enough to make broad decisions about general layouts, and broad consensus around the general design strategy, the design team and mana whenua were not able to come to specific decisions around the placement of the pou whenua. All parties were hesitant to commit until there was better understanding of the three-dimensional context, which became the design team's focus for approach 2.

5.2. APPROACH 2 - PRE-RENDERED THREE DIMENSIONAL MODELS

With broad locations for the pou whenua in place, we started to supplement discussion with static 3D contextual imagery and models, to give participants a better understanding context and scale.

Depending on the target audience, federation platforms may prioritise different elements of the final image. Federation software such as Navisworks present an unembellished representation of live models while supporting analysis capabilities and interrogation of model properties (Autodesk, 2023a), but lack the visual content and hierarchy required to communicate aesthetics (Ayden and Schnabel, 2014). Alternatively, platforms such as DataSmith for Unreal 5 emphasise the visual impacts and aesthetics of a design project but require a degree of post-processing of a static, file-based model for a design model to be presentable (Epic Games, 2023). As was experienced with the method explored in this segment, the long lead time between creating a design change and evaluating the final image means that these techniques were unsuitable for the engagement team to get good design feedback.

For this method, a Grasshopper script was used to model placeholder pou whenua as 3D elements, procedurally adapted to the ground levels of the specific location. These placeholder models were then referenced into a federated model in Rhino to provide context. Rhino worksessions were used to keep the federated Rhino model live. Screen captures were taken of each placeholder model from standard viewpoints at human eye level, and we ensured that each image has a landmark model element (such as a car or pedestrian) in it. The models were captured in Rhino's 'Rendered' view mode which rendered the model as greyscale so that the focus would be on the physical space. To ensure continuity with earlier engagements, we used the same visual language of colour coding elements that may be significant to mana whenua to match and situate the 3D view within the 2D context. This process required a large amount of pre-hui work to make sure everything was visually consistent and was presented in a way that made sense.

During the hui, the engagement team would be able to present these options and receive feedback on those options, but this feedback could not be incorporated into the 3D models within the scope of a single session - if an option was discarded and another idea was put forward by the participants, there was no 3D contextual imagery to support it. Better understanding of the context of the design options lead to more meaningful refinement, but since the results of each iteration could only be generated

between hui. We identified that one of the restrictions with this way of working was the *latency*, the delay between iteration and feedback.

5.3. APPROACH 3 - INTERACTIVE PARAMETRIC MODELLING

The engagement team considered two options to lowering latency: either use a platform designed around the rapid visualisation of parametric models and federating the results dynamically or work directly in the parametric modelling software itself while losing some of the benefits of federation.

There are emerging technologies that allow for generative and parametric models to be directly federated into other applications, which requires the underlying geometry engine and script to be bundled together. Software vendors are beginning to support this kind of bundling as a way of decoupling CAD and BIM design tasks from desktop sessions. For example, McNeel provide a Rhino Compute service that can be run on demand, and Autodesk have the APS Design Automation APIs which are tightly integrated with BIM 360 (Payne, 2022; Autodesk, 2023b).

Within the company, the design team had previously experimented with a range of parametric platforms, including Rhino Compute, APS, Hypar and Shapediver, and had piloted Hypar as part of previous community engagement projects in the Northern Territory of Australia. Hypar's ability to break individual parametric generative processes into BIMs, dynamically regenerating downstream models, was prototyped as part of this type of early engagement and was well received by project stakeholders. However, the scale and fidelity of the contextual modelling that was required to be included in this case study meant that a large amount of pre-hui setup would still be required to place these designs in context.

Having considered a range of technological approaches, the design team continued with Rhino, natively manipulating feedback from scripts using traditional computational design strategies. While the technology is improving, the competing requirements of the project, especially time pressure, meant that the simplest answer was to have a computational design professional present in the sessions. The computational design workflow was already in place because it was used to model the options from approach 2, so it just needed refinement of the parametric design space to be robust enough to handle any edge cases that may come up in-meeting.

During each hui, the engagement team could respond to a broad range of requests for iteration and optioneering in real time, and decisions could be made more effectively because options could be visualised and their impacts on the project analysed immediately, avoiding over-consulting. The use of the federated model meant that the engagement team could also check for clashes with underground utilities in the meeting, which also meant greater transparency around some of the reasoning for decisions made on the engineering side. An unforeseen side effect of the shift to parametric modelling away from static was the freedom given to the participants to explore the model in real time as changes were made. This both highlighted the benefits of shifting to a parametric approach, a more active form of engagement, and the importance of working within a federated design environment – a parametric model in isolation would not have had the same outcome.

6. Discussion - Situating Technology and Cultural Context

From this experience, the design team gained useful insight and experience in partnering with mana whenua, and derived novel learnings about how computational design can be used to enhance this partnership, to be explored further in future work.

Firstly, the design team found that parametric design can be a helpful tool to enable non-professional stakeholders to understand the context and impacts of design decisions. The strength of parametric design in a co-design optioneering context is the ability to codify knowledge held by experienced designers, creating a parameter space within which a range of designs can be visualised and explored, without each option needing to be prepared ahead of time. This also removes the requirement for the experienced designer to always be in the room, allowing for more flexibility around the perspectives involved in the discussion. In the case where parametric models are too complex to be generated at runtime, or where multiple designs need to be compared, tools like Design Explorer have been used to pre-cache design options to great effect (Marschall and Sepulveda, 2022). The freedom afforded from live parametric modelling to explore the model and context in real-time lead to a more active form of engagement, an overall better understanding of the project, and more informed design decisions.

In the world of design visualisation and modelling, vendors are beginning to embrace the idea of a plurality of use cases for any one 3D model, consumed by different end products and transformed as required into other engagement formats like virtual or augmented reality environments (Sheikh and Crolla, 2023). In the open-source community, tools like Speckle are being built using similar architecture (Stefanescu, 2019). These approaches could ultimately provide a solution for incorporating integrated design contextual models into a low-latency parametric context, though more practical testing and research is required.

Secondly, in acknowledging that mana whenua are experts on the history of their ancestral lands, and can therefore make important contributions and create insights and design ideas (Te Arawhiti, 2023b), we also acknowledge that enabling them to fully engage with a parametric model can improve their understanding of the project's components and enable better outcomes. The ability to see, in real time, the impacts of changing the height, the location, or the number of pou whenua in an area meant that decisions could be made on the spot, and iteration was both fast and more certain.

The next step in the development of this method of design partnership is to understand from the perspective of mana whenua what aspects of the discussed approaches they found beneficial to their understanding of the project, and what wasn't when engaging with visual representation. Visual representations play a large part in the perception and therefore the decisions made about of a design project. To ensure visualisations are more inclusive of mātauranga Māori and mana whenua perspectives, we could remove the potential for misunderstanding due to embellishments or technical communication styles by creating spaces and opportunities for mana whenua themselves to be part of the design of the parametric tools and modelling processes used on projects. There is still much to learn in this space, and the process will be different for partnership with every indigenous group.

This research contributes to the tool kit of not only urban designers but any designer

whose work will be used or seen by non-technical people. Urban design has a long history of participatory design as a method of involving the community and stakeholders in design development, but it has been identified that the way designers communicate with non-technical participants can often fall short leading to misunderstandings and missed opportunities (Bates-Brkljac, 2008). In the case study workflows presented in this paper, the use of parametric modelling showed great potential to bridge the gap and enable meaningful participatory design workflows by improving participant understanding, leveraging our shared 3D visual language.

From this experience, the researchers found that computational design extends the ability of designers to use reflective practice by providing context and detail which allows designers - both technical and non-technical- to pull from tacit knowledge and lived experience. Authentic engagement with mana whenua ensured successful project outcomes and alignment with their values and aspirations.

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