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Abstract
There is increasing interest in the technological construction of the cultural artefact. However the uptake of technology may be coming at a cost to the historical values sincere to cultural groups. This paper reports on evaluation techniques applied towards a recent research effort delivering a virtual reality experience that embraced the traditions of indigenous Maori within a learning, language and cultural context. A 3D computer generated artefact was constructed portraying an indigenous Maori mythological story able to interact with cultural objects using Design Science Research (DSR) as a research method, then evaluated as a cultural deployment using an array of evaluation techniques. This article expands the research material available to cultural research in DSR, as well as demonstrating how DSR evaluation can be viewed during the construction of an indigenous cultural artefact.

Keywords Design Science Research, Indigenous Culture, Cultural Artefact, Maori, Evaluation.

1 Introduction

Technology is becoming a one click and view everywhere landscape which is changing the way we communicate, and the way people define their digital selves. While some view culture as a right to live and experience a way of being, others argue technology is a determinant where the fate of culture is caught in the mix of technological advancement (Chirkov, Ryan, Kim, & Kaplan, 2003). For indigenous communities, this creates a constraint between their current cultural ways of doing and the future advancement of culture using technology.

The emergence of immersive technology provides opportunities for indigenous Maori to re-tell their cultural stories as a representation of their digital selves, including their traditions, beliefs and values, portrayed inside a technically savvy environment. As an example, virtual environments allow individuals to alter their digital selves, through the behaviours and attitudes of their avatars (Ganesh, van Schie, de Lange, Thompson, & Wigboldus, 2012).

This research focuses on the evaluation techniques applied to a recent research effort to deliver a virtual reality experience that embraced the traditions of indigenous Maori within a learning, language and cultural context. An artefact was constructed to re-tell a Maori mythological story using Design Science Research (DSR) as a research method, and then evaluated using three evaluation techniques.

This research specifically discusses the evaluation of an artefact constructed using DSR methodology, targeting the question how can DSR evaluation ensure that an IT artefact conveys indigenous culture? The article explores three DSR evaluation techniques to assess a cultural artefact built using a computer generated virtual environment. Literature discussing the adverse impacts and positioning of culture in technology is entered into before turning to three types of evaluation techniques for the purpose of establishing a baseline for future discussion that maybe useful to DSR in the future and, to illustrate how evaluation could potentially benefit cultural understanding during the construction of the IT artefact.

2 Literature Review

2.1. Culture and Technology

One way to study the relationship between culture and IT artefacts is to look at the impact of the IT artefact on social and culture entities. Walsham, (2002 p.360) conceptualises culture as the "shared symbols, norms and values in a social collective". Culture can also be represented in visual form as an artefact. Artefacts can be physical, or they may be sets of rules, models, practices, and structured tasks (Kappos & Rivard, 2008). The increased use of IT artefacts globally has spurred debate as to what degree culture influences the usability of such artefacts. Studies on usability have acknowledged the need to study the impact of culture and the importance of studying the context of the artefact (O'Brien, Levy, & Orich, 2009).

Many IT studies concerned with various cultural aspects have tended to rely on a national model of culture (Hofstede, 1980). However, Hofstede's (1980) model has been described as rather simplistic as creators of IT artefacts have relied solely on generic predefined attributes of culture, which may not be sufficient for success as culture takes many forms where each cultural subset can be described differently (Myers & Tan, 2002). Another way of viewing culture, is to focus on the meaning of an artefact within a social and cultural context (Orlikowski & Iacono, 2001). Hence, culture can influence the design of an artefact and conversely, an artefact may influence culture. One complication, however, is that the adoption of IT artefacts often requires adoption of the creators' cultural norms, values, and practices in order to use the artefacts effectively (Lin & Silva, 2005). In striving to improve understanding of culture, IT researchers have mostly drawn on theories and methods from the social sciences. Theories such as activity theory (Engestrom, Miettinen, & Punamäki, 1999), which has been used to study the relationship between culture and IT artefacts. The artefact may embrace the cultural attributes of its designers, or the cultural attributes of the intended users, or both. The key issue here was for researchers to understand the user and the culture represented (M. O'Brien et al., 2009). The challenge arises when the designer's culture differs dramatically from that of the user. The metaphorical distance of the designer's culture from the users could pose problems to design. This was exemplified by studies of usability in eastern and western cultures (Diaper & Lindgaard, 2008).

3 Design Science Research

In many cases, practical problems can be solved through the creation and/ or use of artefacts. Hevner and Chatterjee (2010) describe an artefact as an object made by humans with the intention that it be used to address a practical problem. They view the artefact as being used to describe something that is artificial, or constructed by humans, as opposed to something that occurs naturally (Simon 1996). In the early years of IT, most artefacts were developed for military and business practices, however in recent times, some of the most innovative IT artefacts have been designed for everyday use (Johannesson & Perjons, 2014). According to (Hevner, March, & Park, 2004), DSR seeks to create and evaluate IT artefacts intended to solve identified problems.

> "The scientific view of design research arises from the concepts found in Simon's seminal The Sciences of the Artificial. Simon's design research involves three fundamental aspects being an imperative or prescriptive logic, a search for alternatives, and the evaluation of design". (Simon, 1996 p.54)

Much of the early DSR focused on systems development approaches and methods as well as constructs, models, and instantiations (Hevner et al., 2004). Work by Ostrowski and Helfert,(2011) observed that literature and collaboration with practitioners played an important role in constructing, producing, and developing an artefact through DSR. Hevner (2007) identified challenges to research with a design science focus which included distinguishing between conventional science research and design science research techniques and outcomes. Critics argue that the practicality of results from building artefacts did not necessarily make the research project applied science, and that a research project could effectively balance goals of fundamental scientific understanding with considerations of the usefulness of the resulting artefacts. Further work completed by Hevner and Chatterjee (2010), was in favour of the proposition that research design activities were situated at the core of most applied research disciplines dating back to the 1940s. In later work, Hevner and Gregor (2013 p337) affirmed DSR as a research methodology that has staked its ground as "an important and legitimate IT research paradigm" whose potential was yet to be fully realised due to gaps in understanding the identity of DSR concepts and methodology.

3.1 DSR evaluation

A central aspect to DSR is the evaluation of the artefact. Evaluation looks to incorporate a rigorous process that includes observation, analysis, experiment, simulation, test and description. Evaluation can occur starting at the conceptual stage of the design research, continuing through the construction phase of the artefact, and after the completion of the artefact to determine the research effort (Chard, Shedlock, & Vos, 2016). Evaluation involves a wide discussion as to "how", "what", and, "when" to evaluate. Hevner et al, (2004) identify evaluation as crucial to demonstrate the utility, quality, and efficacy of the design artefact. Hevner (2004) details how DSR requires the use of rigorous evaluation methods including observational, analytical, experimental, testing, and descriptive techniques as part of the evaluation process. The evaluation of quality and rigor establishes a guideline in relation to evaluation of the artefact design (what to measure) depending on what is evaluated (design process or design product). The following looks at three types of evaluation techniques deployed during the construction of the cultural IT artefact.

3.2 Artificial and natural evaluation

According to March and Smith (1995), evaluation is classified into two primary DSR approaches being artificial and naturalistic evaluation. The distinction between the two is highlighted by Venable, (2006) who believes that natural science is concerned with explaining how and why things are, whereas artificial science is concerned with devising artefacts to attain goals (Pries-Heje, Baskerville, & Venable, 2008, pg.94). There are advantages to both artificial evaluation (such as more control and lower cost) and naturalistic evaluation (more realism). According to Sun and Kantor, (2006) artificial evaluation is viewed as unreal according to the three realities of unreal users, unreal systems with unreal problems (not held by the users and/or not real tasks). Research strategies and methods for different artificial evaluation approaches are further discussed by Johannesson and Perjons, (2014) who adapts work completed by Venable et al (2012) where artificial evaluation consists of methods that involves mathematical logic, computer simulations, lab experiments and informed arguments that involve logic, simulations and field experiments. Natural evaluation is often viewed as consisting of two activities, discovery and justification. Discovery is the process of generating or proposing scientific claims (i.e. theories and laws), whilst justification includes activities by which such claims are tested for validity. Sun and Kantor (2006) described naturalistic evaluation as the opposing three

realities involving real users using real systems to solve real problems to accomplish real tasks in real settings. Naturalistic evaluation embraces all of the complexities of human practice in real organisations. As such, it may be difficult (and costly), partly because the evaluation must consider the effects of many compounding variables in the real world. Naturalistic evaluation is always empirical and may be interpretivist, positivist, and/or critical. Naturalistic evaluation methods include case studies, field studies, surveys, ethnography, phenomenology, hermeneutic methods, and action research. To the extent that naturalistic evaluation is affected by confounding variables or misinterpretation, evaluation results may not be precise or even truthful about an artefact's utility or efficacy in real use (Pries-Heje et al., 2008).

3.3 Ex ante and ex post

Klecun and Cornford, (2005) view artefact evaluation as having two perspectives, firstly at the beginning and during the artefact build known as ex ante and, after the artefact build has been completed known as ex post. Design research considers that the search and the design stages of the artefact build involves a process that includes a user who may represent the beneficial owner, and the designer who communicates with the user to obtain an abstract view of the artefact. This allows evaluation to be introduced ex ante, a process of conceptual planning based upon requirements identification. Furthermore, design research is employed to carry out formative research to test and refine the artefact based on knowledge obtained from the user or literature. This approach of refinement at the ex ante stage of evaluation involves preparing an initial artefact for the real world to observe performance, and then refining the design, and making constant alterations based on learned experience, until all the bugs are worked out.

Ex post evaluation is associated with the artefact post construction, and involves the designer, developer and the user of the artefact post construction. Ex post evaluation looks to measure the artefact construction once the build is complete. Both ex ante and ex post evaluation involves described measures as part of the quality of use metrics. Progressive refinement of the artefact leads towards a form of integrated measure that is iterative where, the designer may update their designs frequently, rather than waiting for a model changeover to improve upon past designs (Collins, Joseph, & Bielaczyc, 2004).

3.4 Heuristics evaluation

Heuristics evaluation of the artefact provides guidance when evaluating the user's perspective of the artefacts interface, an extension of Nielsen's, (1994) "Usability Inspection Methods". Heuristics evaluation can be viewed as a process according to Pries-Heje et al., (2008), where a quality product is the result of a good process. A good process is defined as the set of activities, tools, methods, and practices that are used to guide the flow of production. However, evaluating whether a process is sound is not easy or obvious as the components of the process need to be identified and evaluated against some form of prescribed criteria. Sutcliffe and Gault, (2004) present a method for evaluating the virtual user interface of virtual environments. Their evaluation method uses twelve heuristic assessments which address usability and presence issues in virtual world environments. Their work follows Nielson's, (1994) work with subtle differences as a result of the interaction changes with standard graphical user interface variances when compared with VR user interfaces. These changes include realism and sense of presence within the VR application. The twelve heuristics identified are:

- Natural engagement
- Compatibility with the users task and domain
- Natural expression of action
- Close coordination of action and representation
- Realistic feedback
- Faithful viewpoints
- Navigation and orientation support
- Clear entry and exit points
- Consistent departures
- Support for learning

- Clear turn-taking
- Sense of presence

For Maori, when considering evaluation of the artefact, the key things of interest included the ability for the artefact to deliver a sense of cultural link within the artefact. Furthermore, the inclusion of the Maori language, objects and practices provided the cultural Maori artefact with a perceived sense of being Maori. By applying a Maori cultural element to heuristics evaluation, the artefact is aligning to key practices employed by Maori when engaging with VR (Chard et al., 2016).

4 Artefact Build

The artefact used a 3D virtual environment landscape to re-tell indigenous Maori mythology using VR and Google Cardboard as a tool to interact with and capture Maori traditions. The artefacts virtual storyline was based on the mythical Maori story depicting the beginning of the world where Papa (mother earth) and Rangi (sky father), the mythical parents to the world creation, were separated to establish the world of light (Majid, 2010). The artefact showed a pre and post separation view of the mythology encapsulating indigenous Maori traditions, language, sounds and significant objects.

The design research phase of the artefact outlined the artefacts abstract representing an indigenous Maori world with key objects present within the 3D digital environment to portray a Maori view of the world. The physical artefact build was prepared starting with the analysis and design phase looking at the conceptual view of the artefact using pseudocode and the unified modelling language (UML). The prototype artefact was then logically mapped as an unreal representation of the artefact building methods, objects, prefabs and scripts before constructing the real artefact ex post. Thereafter the artefact was evaluated using DSR techniques within a virtual computer setting to measure Maori practice, knowledge and understanding in a technology based world of the artefact VR (Chard et al., 2016).

4.1 Natural & artificial evaluation

Artificial evaluation of the designed artefact considers an imaginary simulated VR setting with unreal users, interacting inside an unreal system, with unreal tasks measuring the non-empirical and empirical performance of the artefact (Sun & Kantor, 2006). Natural empirical evaluation takes a mental view of the unreal users by evaluating the artefact ex ante during the design research phase of the artefact. Evaluation is completed by means of the pseudocode and diagrams, used as prescriptive evidence of the artefact. The unreal systems ability to instantiate the first person characters function to walk, stop and reset within the artefact UI provides opportunity to determine prescriptive measures of the artificial. As shown in Table 1.

Table 1: Artificial empirical evaluation

Unreal Users	Unreal Systems	Unreal Problems & unreal Tasks
Ex ante mental view of the artefact in theory	Construction of the abstract with pseudocode, wireframe, logic depiction diagram, flowchart of events and conceptual ERD.	Developing pseudocode and diagrams to model the methods, constructs and instantiations of the artefact.
Artefact Walk, stop and reset	Building entities with methods, objects and attributes.	Able to move forward, stop and return to the start position inside the VE

Natural non-empirical evaluation seeks to measure the artefacts realism and the ability of the artefact to provide a sense of immersive presence within its virtual-world setting with real users viewing the real system in response to a real problem with real tasks. (Sun and Kantor, 2006, Pries-Heje et al., 2008, Johannesson & Perjons, 2014). The researcher (real user) considered “things of interest” for Maori to deliver a sense of immersion and realism as part of the evaluation. This was achieved by including familiar objects, sounds and the Maori language within the virtual world setting. As shown in Table 2.

Table 2: Natural non empirical evaluation

Real Users	Real Systems	Real problems & real tasks
Users sense of immersion	System able to walk, stop and reset with familiar language, sounds and images	Methods, constructs and instantiations.
Users sense of realism	System delivers a sense of visual involvement (interaction)	VE able to walk, stop and reset with Maori sound, sight and hearing applied.

4.2 Ex ante ex post evaluation

Ex ante and ex post evaluation looks to apply artefact evaluation at two time-lined stages. The first being at the beginning of the artefact build known as ex ante, and the second after the artefact construction has been completed known as ex post (Pries-Heje et al., 2008). Therefore "when" to evaluate is applied by selecting either ex ante at the pre-construction phase of the artefact build or ex post, after the construction of the artefact or both. This provides some clarity in regards to the timing of evaluation either at the conceptual, logical or post physical phases of the artefact build.

To add a second perspective to ex ante and ex post evaluation, this research considered "what" to measure, for example does evaluation seek to measure the artefact as a product (ex post evaluation) or as a process (ex ante evaluation), or both? The ex ante and ex post evaluation table observes the artefacts construction life cycle as either in the design phase, prototype phase or post construction phase. Each phase requires a set of tasks to be completed which are measured against a set of criteria using a range of DSR evaluation techniques as summarised in Table 3.

Table 3: Ex ante and ex post evaluation

Evaluation	Design Phase	Prototype Phase	Post Construct Phase	Criteria	Evaluation Technique Used
Ex ante	Requirements planning of artefact identifies with Maori Pseudocode UML diagrams	Artefact hierarchy established with structure and functions Entity methods, objects and attributes built and reflect Maori.		Validity Usability Quality Utility	Internal environment evaluation Natural / Artificial evaluation Structure and Functional evaluation
Ex post		Prototype of artefact has been through a round of demonstration, suggestion and refinement that focuses on Maori.	Environment depicts a spatial Maori VR Able to navigate in VE and delivers a sense of being immersed within Maori VE Maori VR depicts a sense of realism	Validity Usability Quality Utility	External environment evaluation Natural / Artificial evaluation Heuristics evaluation

4.3 Heuristics evaluation

Sutcliffe and Kaur's (2004) heuristic's were used as a basis for the heuristic evaluation of the artefact. These descriptors were interpreted using a virtual performance perspective and then aligned to a Maori world view of the artefact. Table 4 demonstrates how these heuristics were used, with observations that explain either the link to a Maori world view of the technology, or gaps that may exist when using the technology.

Table 4: Heuristics evaluation

Heuristics	Virtual Performance	Kaupapa Maori world view	Observation
Natural Engagement	Interaction should approach the user's expectation of interaction in the real world as far as possible.	Maori sounds and images are present within the artefact.	The VE delivers a world that involves the Maori language, sounds, visual representations and objects. The artefacts ability to portray concepts such as mana or wairua is unclear.
	User should be unaware that the reality is virtual. Interpreting this heuristic will depend on the naturalness requirement and the user's sense of presence and engagement.	Users of the artefact are made aware of the cultural/ness of the artefact and provides the user with a closer sense of cultural relationship to the artefact.	As an example, the Maori mythology is included in the artefact as a verbal guideline of introduction with matching visual representations.
Compatibility with the user's task and domain	The virtual environment (VE) and behaviour of objects should correspond as closely as possible to the user's expectation of real world objects; their behaviour; and affordances for task action.	Maori objects within the artefact are present and portray real world objects such as depiction of demi gods, karakia (prayer), whaikorero (formal Maori introduction), taa moko (patterns), whaikairo (carving), pataka (food storage house), waiata/ haka (song), koauau, putatara (Maori instruments).	The VE did not have the processing power to deliver a total VE environment. The Maori objects needed to be scaled down in size to meet the VE processing power requirements subsequently lacking detailed depth in the design models. However, through the use of te reo, the depiction of kawa was possible opening further research opportunities.
Natural expression of action	The representation of the self/presence in the VE should allow the user to act and explore in a natural manner and not restrict normal physical actions. This design quality may be limited by the available devices. If haptic feedback is absent, natural expression inevitably suffers.	Functions are available in te reo. Maori users are able to explore the VE and self-navigate using functions available within the artefact such as walk, reset, stop, and teleport.	The artefact provides a setting scenario that uses common Maori terms during the introduction (splash) scene. The artefact also provides useful Maori terminology and directions ex post.
Close coordination of action and representation	The representation of the self/ presence and behaviour manifest in the VE should be faithful to the user's actions. Response time between user movement and update of the VE display should be less than 200 ms to avoid motion sickness problems.	The artefact provides a sense of Maori involvement that includes navigation tips in te reo such as the function to walk, stop, teleport and reset.	The inclusion of Maori navigation tips would require interpretation for other languages speakers unfamiliar with the Maori language
Realistic feedback	The effect of the user's actions on virtual world objects should be immediately visible and conform to the laws of physics and the user's perceptual expectations.	The research is not aware of any known Maori association when providing realistic feedback in a heuristics VE.	More work required in this form of evaluation for a Maori interpretation of VE realistic feedback.
Faithful viewpoints	The visual representation of the virtual world should map to the user's normal perception, and the viewpoint change by head movement should be rendered without delay.	In the research time available, the artefact did cater for this measure.	Further investigation into the concepts of pono (truthful) me te tika (correct way) ki roto i te ao Maori as a VE measure for Maori in heuristics.

Navigation and orientation support	The users should always be able to find where they are in the VE and return to known, pre-set positions. Unnatural actions such as fly-through surfaces may help but these have to be judged in a trade-off with naturalness (see heuristics 1 and 2).	Using the artefacts teleport function, Maori are able to self-navigate within the artefact. However, there is no Maori word or concept known by the researcher for VE naturalism and self-navigation	Future investigation into the Maori concept that embraces a sense of self navigation, realism and naturalism would be useful.
Clear entry and exit points	The means of entering and exiting from a virtual world should be clearly communicated.	The artefact was able to teleport to specific parts of the VE using self-navigation portals. However, there was no user friendly function to enter or exit the artefact,	The practice of powhiri (guest welcome) and poroporoaki (guest farewell) do exist. This requires further research.
Consistent departures	When design compromises are used they should be consistent and clearly marked, e.g. cross-modal substitution and power actions for navigation.	The artefact was able to teleport to specific parts of the VE using self-navigation portals.	Research into Maori practices such as whakaeke (entry systems) and whakawatea (exit systems) would be a useful future VE exploration.
Support for learning	Active objects should be cued and if necessary explain themselves to promote learning of VEs.	The artefact provides Maori VE cues delivering a sense of Manaaki (caring) for the user involved with the VE.	Manaaki is a term used to provide caring support to the user of VE's that include audio, visual and practical instances for example, the prototype provides an introduction scene for Maori that re-tells a brief story in Maori.
Clear turn-taking	Where system initiative is used it should be clearly signalled and conventions established for turn-taking.	The artefacts function of turn-taking has a verbal audio and written visual cue using the Maori language and objects.	The artefact provided written cues as a timeline and verbal cues using "collision code" to generate the experience of turn-taking. However, there is no similar practice for a Maori definition of this measure using VE.
Sense of presence	The user's perception of engagement and being in a 'real' world should be as natural as possible.	There was a sense of mauri in existence with the artefacts Maori cultural objects and instances consistently reflecting real world Maori instances such as the representation of customs, values and beliefs, language and objects.	The artefacts design activity of the Maori VE artefact depicts a sense of unreal Maori objects with unreal Maori participants connected to the VE interface and used by real Maori participants.

5 Discussion

Indigenous kaupapa (cultural way of doing) Maori research is about challenging the notion of normal that has been constructed by the dominant culture, and seeks to identify and uphold Maori views, solutions and ways of knowing. It is about empowering Maori people, voice, processes and the knowledge in existence. Therefore, the Maori artefact takes on a different meaning when applied to the abstract, proto-type, construction and post construction of the artificial. Looking for prior work to model technology and Maori, an abundance of literature was available to discuss Maori, however, prior theory and research addressing Maori in technology was scarce. As demonstrated in table 5, the artefact constructed during this research was able to partially embrace the cultural attributes of its Maori designer (the researcher), providing a useful channel to re-tell Maori cultural stories and convey traditions as an experience.

5.1 Natural and artificial evaluation

This research evaluated the Maori "things of interest" as prescribed knowledge as discussed by (Gregor and Hevner, 2013; March and Smith, 1995) by applying heuristics and evaluation methods that observed indigenous Maori cultural ways of doing. The distinction between artificial and naturalistic evaluation was useful to determine the level of realism when interacting with the artefact. This provided guidance in regards to identifying process based tasks through observing the artificial. The researcher observed abstract realities being transformed into constructs through the use of pseudocode and UML diagrams making up the logical design of entities to identify the artefacts methods constructs, models and instantiations.

Natural evaluation was useful when addressing real problems by real systems and real users, demonstrated once the product had been constructed in the form of the artefact. This was reflected in the Maori cultural language, music, sounds and images being present as part of the interactive experience of the artefact, delivering a sense of immersion into Maori culture and adding to the VE as an experience. Naturalistic and artificial evaluation embraced all of the complexities of human practice in real-life as discussed by Sun and Kantor, (2006), such as the need for VE's to be interactive, and provide a sense of immersion and presence as well as spatial awareness for the system users. However, natural evaluation required an in-depth understanding of a wide range of complex variables associated with being in the human form i.e. visual, audio and practical interaction within the VE. This reaffirms work completed by Venable (2006) where naturalistic and artificial evaluation could be affected by confounding variables or misinterpretation due to results which may not be precise or even truthful about an artefact's utility, quality or usability in real time usage. These observations provide useful guidance when discussing cultural components during the construction of the artefact, for example employing prayer rituals or invoking decedents as part of the construction elements of the artefact.

5.2 Ex ante and ex post

As discussed by (Pries-Heje et al., 2008; Hevner et al., 2004), ex ante and ex post evaluation was able to be applied to the artefact at two stages. The first being at the beginning of the artefact build (ex-ante), and the second after the artefact construction had been completed (ex-post). Understanding "when" evaluation was occurring provided useful guidance to "what" was being evaluated and "when" evaluation was occurring providing a clearer direction in regards to the evaluation technique applied.

Ex ante evaluation provided an organised way to identify the requirements of the artefact. Ex ante evaluation was ideal as a cost effective formative type of evaluation when seeking feedback in a short period of time. However, ex ante evaluation can result in the artefact being assessed as being better than it actually is, since ex ante evaluation only investigates a conceptual view of the artefact. In contrast, ex post evaluation offered the opposing advantages and disadvantages to ex ante evaluations. Ex post evaluation was found to be useful when observing the actual artefact as a completed product, This involved integrating other forms of DSR evaluation such as heuristics, natural and artificial techniques.

For Maori, building the artificial ex ante and ex post requires a specific understanding and portrait of indigenous Maori processes and practices during the design, prototype and post construction phase of the build. As an example, the artefact scoping exercise requires a beneficial owner relaying the message of the artefact to the design engineer. The clarity of the message received, would determine the quality of the artefact at run-time when communicating with the end-user. This research suggests a beneficial owner who speaks the Maori language and a design engineer who understand the Maori language would result in the design of a sound cultural artefact as demonstrated by the heuristics evaluation.

5.3 Heuristics

The heuristics evaluation looked to Sutcliffe and Gault's, (2004) model of evaluation as a template and proposed twelve criteria for heuristics evaluation matched against an indigenous Maori view of the artefact. Comparative observations were noted as shown in Table 4. An interpretation of a Maori world view was added to the evaluation template to identify "things of interest" from a Maori view point. Thereafter, evaluation considered the extent of which the artefact met these requirements i.e. did an indigenous Maori perspective exist within the artefact. This template matching indigenous Maori view with heuristic criteria was a first known attempt to align Maori "words" and "associated ways of doing" against Sutcliffe and Gault's, (2004) model of VR heuristics evaluation. There were common Maori associations established for seven of the heuristics principles such as natural engagement, compatibility with the user's task and domain, natural expression of action, close coordination of action and representation, support for learning, clear turn-taking and sense of presence. Gaps were identified in the provision of realistic feedback, faithful view-points, navigation and orientation support, clear entry /exit points and consistent departures when a kaupapa Maori context was considered. However, some direction was provided within the observations which may provide useful guidance for future work.

The experience of "feels" natural within the UI was a result of hearing the Maori language being spoken and visually seeing representations of familiar models such as Maori houses with familiar Maori patterns attached. The experience of "feels" artificial, was the result of the character models interacting inside the UI in a stagnant manner causing jitter. This provided a sense of unreal immersion which was partly due to the time requirements in preparing modelled characters with high-polygon counts and, the processing power of the hardware to drive the character models.

6 Conclusion

In applying fundamental processes of indigenous Maori understanding and knowledge to DSR evaluation, this research has shown that DSR accompanied with ex-post, ex-ante and heuristic evaluation can provide an outline against which the cultural nature of the IT artefact can be tested.

The construction of the artefact provided insight into how virtual reality as a technology can be used to portray an indigenous Maori perspective, and was a proactive attempt to find a way to deliver a VR experience that embraced the traditions of Maori. VR as a technology has the potential to offer a broad range of opportunities that would be useful and beneficial to the Marae, Maori language, and historical traditions of Maori through ensuring the artefact reflects cultural values.

The use of design science as a methodology for this research topic involved a well-discussed set of processes with clear steps being implemented at each phase of the research project. The artefact used a prescribed model as a process for constructing the artefact, and current DSR theories to undertake evaluation activities.

Evaluation of the artefact assisted the research in producing a DSR outcome that was valuable, rigorous, and a positive direction for future research when working with Maori and DSR domain experts interested in cultural research. Evaluation activities throughout the life cycle of the artefact build, reinforced the focus on the cultural nature of the artefact.

7 Future work

Whilst work has started looking at an indigenous Maori based DSR evaluation framework, ongoing opportunities exist linking the Maori culture to DSR and the development of a cultural theory in DSR. As per the work completed by (Simon, 1996), the researcher leaves open further discussion regarding the evaluation of Design Science Research and Maori for the purpose of building more accessible material as a contribution such as, the application of fundamental processes of indigenous Maori understanding and knowledge to DSR or, the strengthening of kaupapa and the impact of new technologies to Maori.

Evaluation of the artefact was defined to learning more about the evaluation of design leaving further opportunities to link external evaluation of the artefact, by involving expert assessment, or impact assessment on general users for both Maori and non-Maori. Other future work identified building cultural repositories and using traditions as a staging area to build other types of VR worlds such as VR Marae settings or VR Maori language centres. By increasing the number of VR channels available to Maori, this would also provide opportunities for future Maori analyst, designers, developers and researchers. The involvement of a kaupapa Maori context in VR and DSR was defined to a small area

of the Maori cultural domain being the language, practices, processes, values and beliefs leaving wide spaces for further investigation in the future.

8 Limitations

This research considered three topics being Maori, DSR evaluation and VR which were not governed by an overarching body of work. Therefore evaluation guidelines used were based on the literature review and the demonstration of the artefact. With such a large research space under consideration, it was difficult to employ comprehensive evaluation techniques against all three topics. Although design science provides a suitable research method, this method does not provide a formalised set of steps for conducting the construction of the artefact and uses models of work as part of the report. Other digital cultural models may exist in the form of building the cultural artefact. The theory of DSR is increasing with the discussion of different DSR perspectives such as DSR modelling, strategy, processes and evaluation. DSR domains involving complex artefact interactions may not be covered in this research.

Whilst the research was intended to focus upon evaluation of the cultural artefact, this project was never intended to test the importance of Maori as part of the design team. The complexity in dealing with indigenous cultural topics in design comes from personal experience and what the researcher has previously observed rather than from any research structure as a point of discussion.

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