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O-TŪ-KAPUA ('WHAT CLOUDS SEE'): A MIXED REALITY EXPERIENCE BRIDGING ART, SCIENCE AND TECHNOLOGY IN MEANINGFUL WAYS

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Abstract

Mixed Reality learning environments can provide opportunities to educationally enhance previously isolated scientific concepts by using art and technology as mediums for understanding the world. Participatory experiences provide a kinetic means of comprehending often-abstract knowledge, creating the conditions for sensory learning that is inclusive and accessible. The O-Tū-Kapua (what clouds see) Mixed Reality experience provides an inverted view of the environment. Rather than us looking up towards the sky, the clouds look down upon us. Atmospheric science is personified through an intertwined narrative that begins with creative action. Participatory learning embedded within technology-enhanced education creates opportunities to question how as educators we can create opportunities for integrating art, science and technology, enhancing our ability to capture young people in conversations about the socio-ecological Anthropocene.

Keywords

Mixed Reality; technology-enhanced learning; self-determined learning; art and science education

Introduction

This project was part of a larger climate change initiative known as TEMP (see http://www.tempauckland.org.nz), focusing on climate change in the era of the Anthropocene (Taylor & Pacini-Ketchabaw, 2015). Five teams of artist(s) and scientist(s) were invited to collaborate in the creation of high impact participatory experiences presented as a series of events and installations during March to May 2017 within two hubs: Corban Estate Arts Centre in Henderson, and Te Uru Waitakere Contemporary Gallery in Titirangi. O-Tū-Kapua (What clouds see) was the multimodal creative learning environment produced by the 'TEMP_Air' team, who were tasked with raising awareness about the importance of air and air quality. The team consisted of F4 Collective, atmospheric scientists from NIWA (National Institute of Water and Atmospheric Research), researchers from Auckland University of Technology and a private sector Augmented and Virtual Reality company.

The TEMP_Air team researched and developed strategies over a two-year period that would creatively introduce a range of science concepts to west Auckland tamariki. Loosely building on the New Zealand Level 5 science curriculum, *Making Sense of the Living World* (Ministry of Education, 2007), the team investigated how air quality might be incorporated into a holistic conversation about our interrelatedness with the environment. Integral to this was questioning how the project could combine analogue-making with interactivity and mobile technology. Employing a sensory methodology (Pink, 2015), the team focused on developing participatory multisensory experiences that could spark conversation and curiosity to foster learning about birds and insects that live in New Zealand's native forests, the life of the trees and by necessity coming to understand our shared dependency on air.

O-Tū-Kapua combined the personal and imaginative haptic world of the child through their individual artistic efforts, with a place-based educative narrative (Penetito, 2009), linking their creative endeavours to scientific stories about the flora and fauna sharing their local habitat. Embodying the living world, their artworks flew and perched amongst the branches of the fictive forest creating an immersive and engaging visual world, a vibrant habitat brought to life through their collective efforts. Hidden amongst this profusion were Augmented Reality (AR) markers disguised as drawings.

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Discovering them allowed tamariki to perceive the secret life of the forest. The O-Tū-Kapua app extended the sensorial through composed sounds, representations of the plunking rain, the call of the birds, and the music of the Hauāuru, the west wind, as he plays music with the plants and trees. The health of our atmosphere and the trees were pictorially embodied, each element revealed through a digital extension of the haptic. Technology and analogue making conjoined to create an experiential sensory investigation of the living world.

Designing O-Tū-Kapua

From the outset O-Tū-Kapua was designed to engage tamariki (primarily focusing on 8 to 10 years of age) through activation of the senses, and to create meaningful connections (Thompson, 2002; Tilbury & Wortman, 2008). Rooting the project in the local, in this instance, the Waitakere Ranges (the largest forest present in West Auckland) provided an anchor, enabling the connection of basic concepts of atmospheric science with more integrated concepts and notions of ecological thinking and literacy (Orr, 1992; Sterling, 2005). Coupling a Place-Based Educational framework with a sensory methodology, the team aimed to create a pedagogical agent capable of being activated in differing circumstances and through different means (analogue hands-on, aural, digital, in-context and connected modes of learning). A Mixed Reality quest-based experience was used to augment learners' meaning-making by enabling participation in media-rich environments (Pachler, Bachmair, & Cook, 2010). Learners were engaged in perceptual exploration and contributed to the creation of a forest-like metaphorical environment (through school workshops). They investigated and located hidden worlds within the forest (with and without the assistance of mobile devices), all the while seeing and perceiving the world they inhabit and that inhabits them through situated and embodied science. In this relational world, curiosity and pondering are concomitant with wonder.

Throughout the nearly two-year development of the project, O-Tū-Kapua engaged eight key individuals, most of who work in the tertiary sector, as well as an industry partner and a small group of postgraduate students. Everyone who worked on this project was motivated by the belief that tamariki from New Zealand, and across the globe, will increasingly be faced with environmental and societal issues related to the earth's changing climate. During the planning of O-Tū-Kapua the team grappled with widely held beliefs that young people were not able to engage with climate science concepts. Any form of public discussions around the mechanisms, impacts and options for adaptive behaviours predominantly exclude the input of tamariki. However, the research team agreed it was essential to foster creative and constructive conversations about air and air quality, especially amongst the young, if we are to develop an interrelated conception of *environment*.

Technology-enhanced learning in practice: The O-Tū-Kapua Mixed Reality experience

Whilst delivered through the mechanisms provided by being an art exhibition, O-Tū-Kapua remained steadfastly an educational endeavour. Developing a Mixed Reality (MR) environment (FitzGerald et al., 2013) required a framework that supported movement between the analogue and digital experiences, which encompassed the real environment (present at the gallery space), integrated with a set of digital affordances ('possibilities' offered by digital tools). The digital components of the MR environment included Augmented Reality (AR), aural soundscapes and an app-based 360 degree panoramic tour of the Waitakere Range that could be viewed in Virtual Reality (VR) mode through cardboard VR headsets (provided as part of the installation). The MR was complemented by a website supporting extended inquiry through the provisioning of links to a large variety of online resources and social media (see https://www.otukapua.nz/), enhancing the emphasis in O-Tū-Kapua on sharing and connecting. MR environments fundamentally blend paradigms, providing a perfect context for developing an integrated multimodal approach. In this instance, the tamariki were pedagogically supported to contribute, through art-making (Figure 2), to the construction of a real environment; one they could walk around in and identify their contribution and those of their peers. They could show their whānau their artwork and speak through their newly acquired knowledge about the birds, insects and trees and our shared need for good quality air.

Though constructed in a gallery (Figure 3), this experience could, and has been, reconstructed in a classroom. Supporting this physical reality is a secondary experience that is accessed through mobile technology, iPads, tablets or smartphones. The app magnifies the experience and extends the narrative.

Housed inside the app is a hand-drawn magnifying glass (Figure 1), which is used to locate the AR component of the MR environment, mirroring a real world scientific investigative technique. With MR, as opposed to Virtual Reality or app-based games, the mobile device can operate as a social agent. Participants are not disconnected from the collective experience, as they would be if they required a VR headset or were connected to the world of the game. The AR enhances collective wonder because it is situated and embodied in the real. It is this intertwining that promotes face to face communication and discussions; together the analogue and digital manifestations of reality orchestrate shared experiences and thus social learning.

By combining digital and analogue stimuli, O-Tū-Kapua aimed to promote exploration through individual and group-based active learning. Using markers (Figure 4) to create activation points readable by the view of the camera on the mobile device, much like a QR code, a layer of digital information (e.g., animation, sound and data visualisations) was added to the physical, sensory worldview. MR allows for the integration of real and digital information as a combined experience (FitzGerald et al., 2013). Motivated by encouraging tamariki to pose and seek to answer questions, we shaped the exhibition to represent a self-determined learning space. Tamariki and gallery visitors were able to create their own learning content and context (Aguayo, Cochrane, & Narayan, in press; Hase & Kenyon, 2013) with or without the assistance of mobile devices. Loosely orchestrated through a quest concept, additionally, the team provided students and the general public with a folded, double sided A4 booklet as an entrée to the quest (Figure 5). This approach stimulated physical exploration of the environment (the forest setting constructed in a gallery) as well as through technology, creating an ecology of resources (EOR) (Luckin, 2008) and facilitating an integrated technology-enhanced learning environment. A hand drawn magnifying glass (Figure 1), present throughout the experience and built into the O-Tū-Kapua app (https://www.otukapua.nz/the-app), reinforced the notion of looking thoughtfully and with purpose.

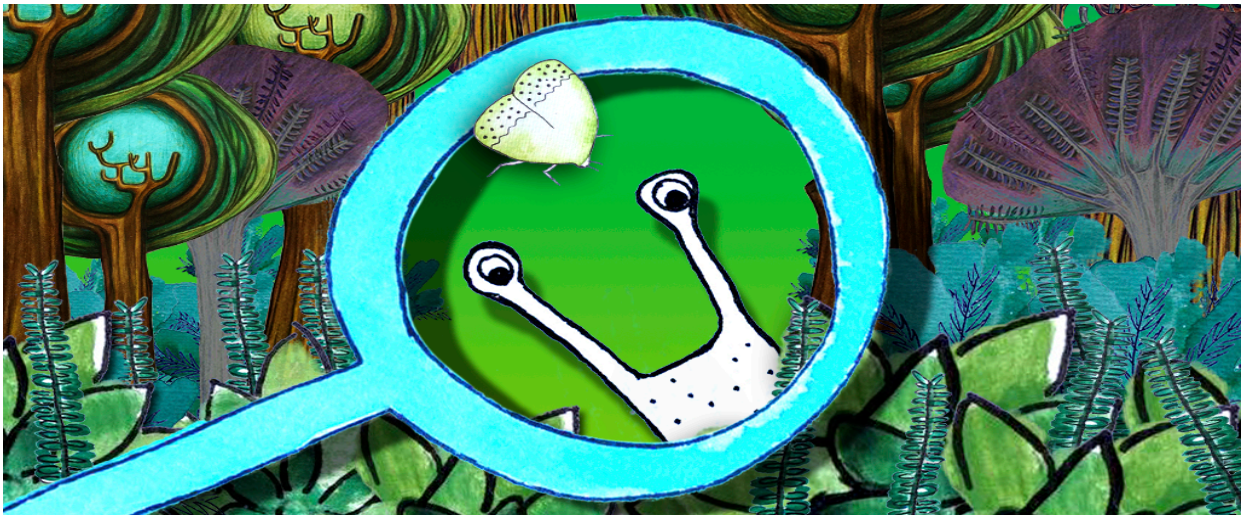

Figure 1: Representation of the quest concept through the use of a magnifying glass (source: S. Jowsey).

O-Tū-kapua's meta-narrative was underscored by the project's sensory methodology. Collectively we compose, support or destroy the ecosystem we inhabit. By making the birds, insects and leaves for the trees, the tamariki gain awareness. Individually and as a whole they were instrumental in enabling the habitat to fill with life. Through the app, life gained additional sensory dimensions, sound and movement, whilst every aspect of the MR experience responded to touch. The majority of AR markers triggered aural soundscapes. Enlivening an otherwise silent visual world the sounds created by Māori composer Maree Sheehan, used contemporary instruments, taonga pūoro (traditional Māori instruments) and voice, fused Western scientific concepts with Māori cosmologies. The forest is an ecosystem essential to maintaining life, and a sentient being, an embodiment of the gods, in this instance Hauāuru.

The aural dimension manifests the incorporeal, where the evocative coalesces with familiar sounds: the wind, the rain, the songs of birds and insects. Making visible the invisible, linking the socio-

cultural space of learning (what is being taught) with the personal space of the learner (the learner's existing knowledge, either learnt or experienced) (Aguayo, 2016). Predicated on the belief that there are different ways of explaining the world we live in, O-Tū-Kapua demonstrates that what may be perceived as ordinary is in fact extraordinary.

Figure 2: School hands-on workshop where students made bugs and birds to go in the forest environment (source: Unlocking Curious Minds, 2017 (left) and Te Uru Waitakere Contemporary Gallery Educational Team (right)).

Figure 3: O-Tū-Kapua installation and exhibition space. Workshop bugs and birds were continuously added to this evolving learning space (Source: Te Uru Waitakere Contemporary Gallery Education Team).

Figure 4: Tree stump AR marker (source: F4 Collective © - left). The triggered AR tree visible using the O-Tū-Kapua app (source: F4 Collective - right) shows real-time weather and traffic conditions in Auckland. Try it yourself by downloading the app (freely from app stores for iOS and Android devices).

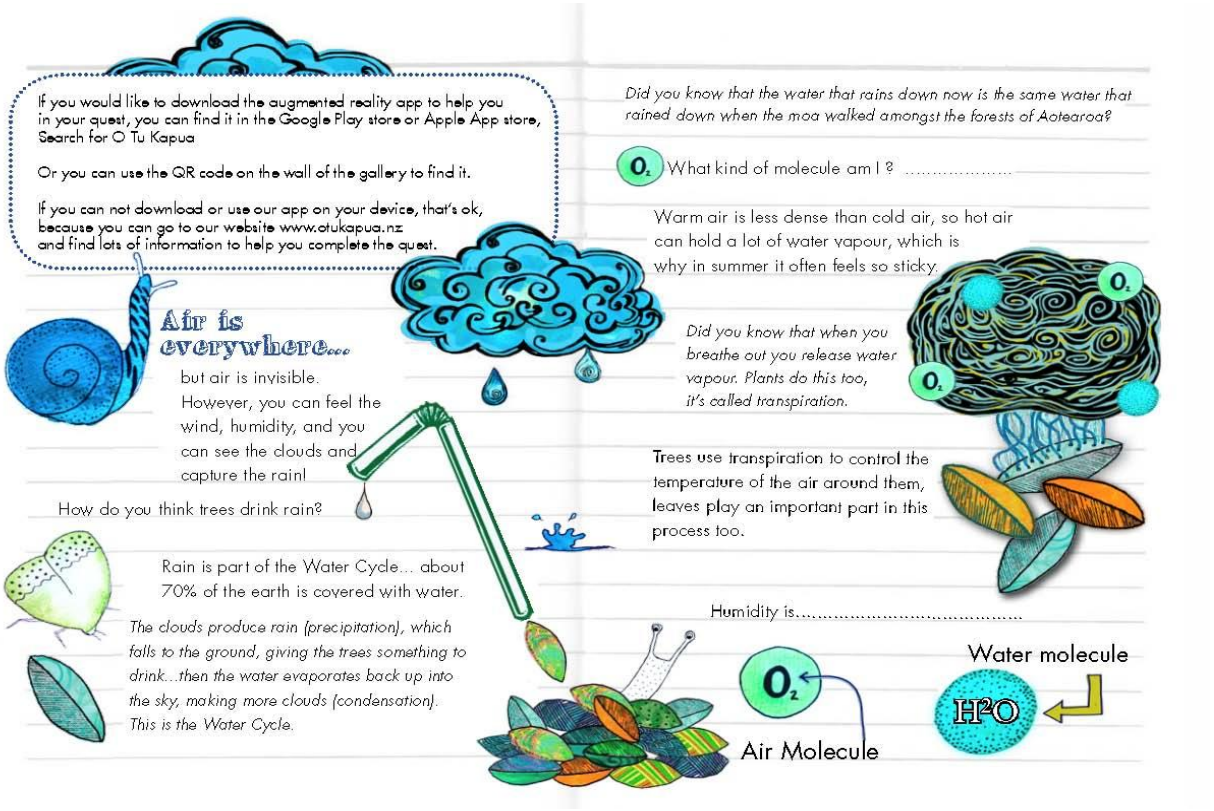

Figure 5: The A4 folded booklet (source: F4 Collective ©) download from the O-Tū-Kapua website.

Whilst each aspect of the MR experience was interwoven conceptually and aesthetically, the main strands were designed so that they could exist, and remain effective, independently. Visitors to the exhibition did not have to attend the workshop to understand and explore the exhibition, or need the

app in order to be intrigued and curious about the quest. Employing pedagogical link-making that focuses on how "connections between ideas in the ongoing meaning-making interactions of classroom teaching and learning occurs" (Scott, Mortimer. & Ametller, 2011, p. 3), the team sought to provide a multimodal journey. Utilising creative thinking, the TEMP_Air team explored principles such as predict, observe and explain, illustrate ideas, experiment, collaborate and reflect (Linn, Bell, & Hsi, 1998; Mehlenbacher, 2010) infusing them into the design of the project.

Learning outcomes

O-Tū-Kapua staged the asking of speculative questions; for example, a marker that depicted a tree stump, when viewed through the app, showed a tree. The health of which responded to real time data pertaining to Auckland weather and traffic conditions. This data stream was collected from various sources and refreshed every 10 minutes (Figure 4). The responsive nature of the tree set the stage for a host of questions and hypotheses about what was happening to, and within, the immediate environment of the tamariki. Whilst you can look out a window or stand outside and make predictions about the weather, it is hard to envision how much pollution is in the air, unless you can see or smell car exhaust or wood smoke. Creating pedagogical links between curricula and lived experience frames interconnections from which larger conceptual webs or patterns can be formulated (Scott, Mortimer et al., 2011; Sterling, 2005).

This form of mediated learning can sustain a longer-term engagement with the subject; abstract scientific notions concretise through associative thinking. A simple concept such as air is all around me including inside me, can change the way air is perceived. Air is not an abstract blue field viewed as the sky, it fills my lungs and those of the birds in the trees outside. Threaded through O-Tū-Kapua are familiar and unfamiliar notions of air (Figure 6). Exploring the world through a microscope reveals the unseen, the human propensity to wonder and to imagine. To be curious has provided the impetus to develop technologies that reveal, if not necessarily explain what is hidden from the human eye. MR offers a mechanism for combining established teaching practices with technology based experiences in transformative ways (Aguayo et al., in press), where AR is augmentation of reality that is *constructed*, created by the tamariki as part of their learning experience.

Figure 6: A primary school class engaging with the exhibition space (Laura Goodall/Curious Minds NZ, 2017).

Concluding remarks

The creation of O-Tū-Kapua taught the research team a lot about how Mixed Reality environments can support a deeper connection to scientific concepts, not just for tamariki. The project received positive responses from participating schools as well as the wider community. Feedback from Te Uru Waitakere Contemporary Gallery stated that "people of all ages and abilities have engaged with this exhibition. From 2 year-olds spending an hour looking at the bugs and learning about the forest while enjoying the app, through to elderly people who have embraced the technology and appreciated the stunning children's artwork. Home school groups have spent long periods of time in the gallery, sketching trees and using the app to develop further understanding on our local environment and climate science". Fascination and curiosity is not the sole domain of the young. We should all be allowed to marvel, not at technology but at the wonder of the world we inhabit. Mixing realities can prise open the human capacity for sensory-based inquiry, simultaneously feeding our hunger for embodied, emplaced understanding.

This project raises many questions about how learning opens opportunities for integrating artistic expression and narrative with scientific concepts, the role of technology, and our ability to capture young people in conversations about the Anthropocene and our engagement with the invisible.

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Glossary of te reo Māori words

O-Tū-Kapua	What Clouds See
Tamariki	Children
Kaiako	Teacher
Whānau	Family
Taonga pūoro	Traditional Māori instruments
Hauāuru	is the playful west wind

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