

He tohu o te wā – Hangarau pūtaiao / Signs of our times – Fusing technology with environmental sciences

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Auheke: Kua wetekia te hunga rangatahi i te ao tūroa ki tō ngā tūpuna, ngā mātua ō mua. He noho tāone e tupungia ai e te taupori o te ao, ā, ko te nohoanga Māori te wheakoranga e mate haere ana. I te tau 2018, i whakahaerehia e mātou ngā papamahi e 8 ki ngā tauira 13 ki te 17 tau te pakeke nō ngā Wharekura e rua kia whakatōmenehia te whakatinana o te mahere Cultural Monitoring. Ahakoa i whai hua te urunga o te Cultural Monitoring i roto i ngā papamahi pūnaha hauropi, he wero nui kia mārama ai ki te pokapū o te reo hauropi. Ka pupuke ake te hihiri mō te mātauranga taiao me te hauropi i te huringa o ngā akoranga ki te ao ake o rātou mā, arā, ko te ao hangarau, ko te ao matihiko, ko te ao kēmuranga. I whakamātauria ngēnei akoranga hangarau hei whakahihihi i ngā whanonga taiao kia pupū ake ai te reo o te taiao, te mātauranga Māori hei tautoko i te hononga ki te whenua, ki te ao tūroa. I roto i tēnei whakākoranga i waihangatia tētehi kēmu tūāpapa e pā ana ki te hauropi o Aotearoa. Ko Eko te ingoa o te kēmu nei. He kēmu e tuitui ana i te tuāpapa o te ariā hauropi ki te Mātauranga Māori kia whānui ake te maaramatanga ki te taiao. Ko te mānuka kei mua i te aroaro o ngā rangatahi me te ao tūroa, ko te whakatōmene i te āputa o te taiao, te hangarau me te Mātauranga Māori. I roto i ngā raraunga, ko te 90% o ngā ākongā i ngākau hihiko, ngahau mai ai ki te kēmu, ā, ko te 65% i mau, i whiwhi i ngā akoranga hōu. I whakakitea e mātou, ahakoa e tupu mai ana te mate wheakoranga o te nohoanga Māori huri noa i te ao, ko te ao hangarau pea te huarahi hei whai kia tupu te toi, kia ora te toi i roto i te reo hauropi, Mātauranga Māori, me ngā whanonga taiao. Nā runga anō i ngēnei kōrero, me akiaki te tangata ki te whakatoōene i te auhatanga o te ao hangarau hei hua torowhānui i te tuituinga o te hunga rangatahi ki te ao Tūroa.

Abstract: Youth of this era are more disconnected from the natural world than their predecessors. Global populations live increasingly in urban landscapes, which creates an ‘extinction of experience’ when interacting with nature. In 2018, we facilitated 8 workshops with students aged 13 to 17 from two Maori immersion schools (Wharekura) to explore the application and implementation of a cultural monitoring framework. Although initial workshops demonstrated it was possible to apply the cultural monitoring method across ecosystems, the absence of basic ecological literacy was a significant challenge. We observed that uptake and understanding of basic environmental knowledge and ecological literacy increased markedly when we used gamification. We tested the potential of technology to enable pro-environmental behaviour and increase environmental literacy and indigenous knowledge to support student’s connection to the natural world. Over the duration of this study, we developed a basic New Zealand ecology game, called Eko. The game fuses basic ecological concepts with indigenous Maori knowledge to provide a holistic view of the environment. Our survey results show that 90% of the students found our game entertaining, while 65% reported new knowledge acquisition. Our research revealed that while ‘extinction of experience’ in this area is rising globally, technology can be used as a mechanism to facilitate an increase in ecological literacy, indigenous knowledge, and pro-environmental behaviours. Our challenge in reversing the disconnection between our youth and the natural world is to explore the void between environment, technology, and indigenous knowledge. People should therefore be encouraged to explore how technological innovation can augment holistic solutions when connecting youth with their natural world.

Keywords: Digital platforms, environmental education, environmental literacy, ecosystems, gamification, kaitiakitanga, kaupapa Maori, matauranga Maori, pro-environmental behaviours

Introduction

Māori have been kaitiaki (agents of action to keep, preserve, conserve, and protect the natural resources with which we co-exist) in New Zealand over their natural world for more than 269 years (Roberts et al. 1995; Royal 2003; Harmsworth & Awatere 2013; Wehi et al. 2019). Marsden (Royal 2003) defines the Māori world view as a “series of interconnected realms separated by aeons of time” from which cosmic processes are unified and bound together by spirit. Through this holistic lens Māori do not separate the secular and spiritual or compartmentalise and isolate one institution from another; therefore environment is intrinsically linked to our well-being and the natural world in which we coexist (Awatere & Harmsworth 2013; Collier-Robinson et al. 2019; Michel et al. 2019; Veale et al. 2019). Disconnection from the natural world is paramount in contributing to the loss of our cultural identity as Māori, so ‘extinction of experience’ reflects an erosion of our cultural ways and values (Chan et al. 2016, Walker et al. 2019). Of critical concern to Māori is that through the loss of environmental connection we also lose the transferral of intergenerational knowledge which sustains the living legacy of our culture (Chan et al. 2016; Wehi & Lord 2017; Whaanga et al. 2018, Walker et al. 2019). Youth are seen to be the holders and transferors of that cultural knowledge and well-being for future generations (Turner et al. 2004; Maffi 2005; Whaanga et al. 2018).

Professional environmental societies and publications globally have been describing the disconnect from nature for decades (Pyle 1993, Miller 2005; 2016a). Pyle in 1993 proposed ‘extinction of experience’ to raise awareness of the increased alienation of youth, due to urbanisation (Turner 2004; Miller 2005). The acceleration of urbanisation has been a key factor in the decline of biodiversity, as natural habitats are being transformed into modified human-dominated environments (Miller 2005; Cox et al. 2015, 2018; Soga et al. 2016a, b, c; Diaz et al. 2019, Walker et al. 2019) Recent figures show that 55% of the world’s population resides in urban areas, with a predicted increase to 68% in 2050 (United Nations 2018). In New Zealand main and large urban area populations are already at 66% (Statistics NZ 2018). The challenge that urbanisation poses is reconnection to nature within the urban settings is difficult, this has been extensively examined by urban planners, ecologists, environmentalists and conservationists (Turner et al. 2004; Awatere & Harmsworth 2013; Chan et al. 2016; Peters 2016, Walker et al. 2019). Kaitiakitanga is our cultural institution that enables us, as agents of protection and conservation of our environment, this philosophy persists in most indigenous cultures, so there remains an urgency in our traditions being passed on to our young for cultural resilience (Royal 2003; Beckford et al. 2010; Wehi & Lord 2016; Cisternas et al. 2019; Wehi et al 2019).

Experiential techniques are proven learning techniques defined by Beard and Wilson (2006) as the “sense making process of active engagement between the inner world of a person and the outer world of the environment”. The active engagement of a person is the basic tenet of experience, where the whole person is engaged through their thoughts, feelings and physical being (Beard & Wilson 2006; Gardner 2013). The experiential use of natural resources for contextualising learning offered a unique opportunity to explore the multidisciplinary of environmental sciences, which is more effective in the application of knowledge by students (Vandenbosch 2007; Smith 2012). The contextualisation philosophy forms

connections between the ecological landscape, the community, its culture, and the people who claim allegiance to that place (Beard et al. 2006; Gardner 2013). In the study by Bauerle and Park (2012), experiential learning techniques that were place-based, were seen to engage students cognitive, emotional and physical faculties. These teaching methods demonstrated gains in achievement (Bauerle & Park 2012), improved critical thinking and problem solving (Ernst & Monroe 2006), increased engagement, knowledge acquisition and application (Lieberman & Hoody 1998; Emekauwa 2004; Turner 2004).

Technology is the contemporary form of communication, interaction, and connection for youth globally. Educational engagement with technology has been correlated with increased academic achievement, knowledge acquisition and application. In the literature review on ‘Gaming in education’ by McClarty et al. (2012) they found that games can facilitate learning through motivation, engagement, adaptivity, simulation and collaboration. These findings were supported by a New Zealand study by Calder et al. (2014), who reported that the use of digital platforms in teaching Māori youth made a significant difference in engagement levels. Key guiding values in this study were connecting ‘People to People’, including past, present and future generations, and ‘People to Place’, (Toimata Foundation 2015) embracing all elements of the physical, spiritual, and living aspects of the world. These principles support the values of empowerment, whanaungatanga (interconnectedness of all living things), manaakitanga (care for others), aroha (love and compassion), intergenerational connection, diversity and creativity, restoration of ecosystems, and the revival and survival of te reo Māori (the Māori language). These values determined the tikanga (protocols) on the marae (Māori communal meeting place) and within the spaces with which we engaged.

The aim of this research project was to connect Māori students to the environment or their place, and as such, enable kaitiakitanga, utilising novel and up to date technological innovations.

Methods

We used ‘experiential’ and ‘contextualised’ techniques, both key learning techniques in education to optimise learning potential. We used contextualisation to emphasise location, namely their own regional locations, as a resource tool for connecting with and being enablers of kaitiakitanga in the whānau (family) as well as the iwi (tribe) or wider community context (Nation 1993; Vandenbosch 2007). Contextualisation can obscure subject boundaries drawing into focus the whole picture, aligning harmoniously with mātauranga (Māori knowledge) and pūtaiao (environmental sciences).

We used the freshwater monitoring framework described by Awatere et al. (2017) to establish the cross environmental domains in our methods. This framework enables kaitiaki to understand how western science and mātauranga Māori could be integrated to observe and assess environmental health under a Māori paradigm.

The two case study groups are Te Wharekura o Maniapoto (TWOm, in Te Kuiti) and Te Wharekura o Rakaumanga (TWOm, in Huntly). Both Māori total immersion schools are located in rural areas of the Waikato region (Fig. 1; Ministry of Business, Innovation and Employment 2017).

This research followed the social ethics process developed by Manaaki Whenua - Landcare Research with approval for the project (under the UCM contract C09X1810).

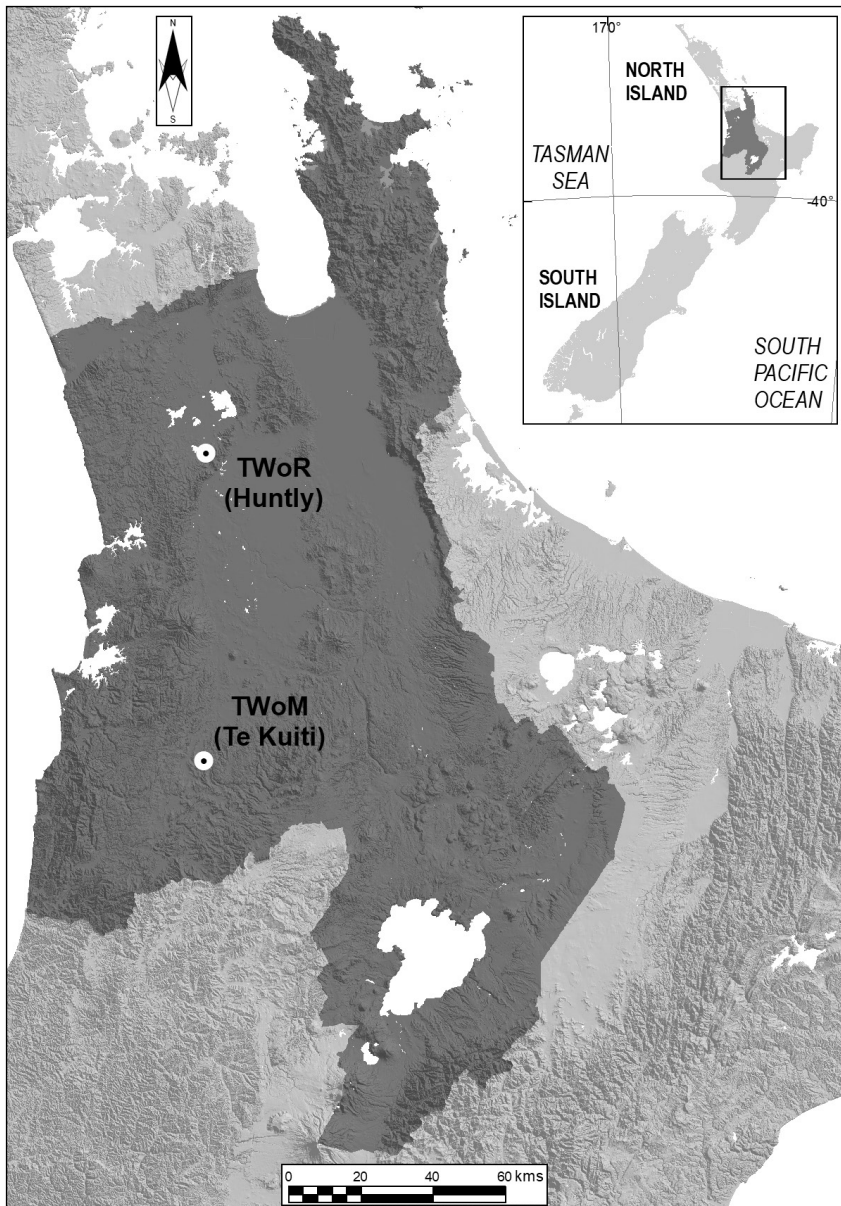


Figure 1. Location of wharekura – Maori immersion schools – TWoR and TWoM within the Waikato region, New Zealand.

Integrated research approach

A mixed methodology research approach was utilised for this project in 2018. This included interactive sessions, noho wānanga (Māori learning experience held on Marae), field trips to various ecosystems – moana (sea), ngahere (forest), awa (rivers and lakes), and repo (wetlands), and surveys. A pre-project and post-project survey collected demographic information and student's everyday interface with science, and a digital survey captured their response to digital use, and the design aspects of the digital platforms.

The research approach utilised the guiding values of Te Aho Tū Roa (A Māori language-based program for schools and communities), embracing Māori culture, language and wisdom (OECD 2017). The two learning experiences of each kura (school) were determined by kura policies, including engagement outside classroom teaching times and competing external obligations to iwi, hapū (sub tribes) or whānau events such as Kīngitanga (a Māori King movement celebrations), poukai (Māori King movement regional gatherings), secondary

schools kapa haka (Traditional Māori arts and entertainment competition) nationals and Te Matatini (New Zealand national kapa haka competitions) that were being held throughout the calendar year. During the introductory visit, the process, approach, and potential outcomes for the participants and beyond (e.g. whānau, iwi, community) were explained. The participants' description and process for each school is in Appendix S1 in Supplementary Materials.

Researchers were able to assess the pre-existing ecological knowledge base of students from fieldtrips. The interactive sessions and surveys also provided information for the digital platform design at various stages of its development.

The interactive sessions and workshops, where possible were communicated in te reo Māori only, however some concepts and ideas utilised in this program were communicated in English. Although the platforms were designed by the wharekura, Māori immersion students, they will be released as a bi-lingual resource and made available to public and Māori immersion schools across New Zealand.

Interactive sessions and surveys

Multiple interactive sessions and surveys were conducted to collate best approach practices for developing the monitoring framework. These included:

Interactive sessions

These were facilitated by the researchers utilising the Technology of Participation (ToP) method (Institute of Cultural Affairs 2018), a collection of methods and tools for collaborative learning, planning, problem solving, and decision making. The focused conversation method was used and followed the ORID (objective, reflective, interpretive, and decisional) framework, so that students were asked a series of questions after visiting an ecosystem (Appendix S2 in Supplementary Materials).

App design surveys

These consisted of 11 questions designed to capture responses from students on the various design aspects of the digital platforms (Appendix S3 in Supplementary Materials).

Eko game survey

This survey consisted of 7 questions to capture the responses to the gamification platform (gamification is the application of the typical elements of game playing to other areas of activities, e.g. point scoring, competition with others, rules of play; Appendix S4 in Supplementary Materials).

Feedback from students was organised according to the Wai Ora Wai Māori mahinga kai (a traditional food gathering site) monitoring tool (Awatere et al. 2017; Taura et al. 2017). The tool was adapted for this project so that students recorded their feelings and reflections according to three categories: taiao ora (flourishing nature); whānau ora (thriving families); and mauri ora (The essence of the living vitality).

To visually present their views, we utilised word cloud analysis to identify and convey different values, feelings and reflections about the environmental domains as reported by students. The word clouds were generated by analysing the relative frequency with which individual terms were used by students according to the three categories, using the online word counting tool (see www.wordclouds.com; Fig.2).

Demographic and science interface information

Pre-engagement surveys. These consisted of 17 questions to capture demographic data, and their interaction with, and level of interest in science.

Post-engagement surveys. These consisted of 19 questions to capture demographic data, and whether their interaction with, and level of interest in science had changed.

Digital platforms

The digital platform was used to assist the student in learning about basic ecological concepts. The development process for the platforms included:

Prototype quiz “Basic NZ Ecology”

The Kahoots platform (a well-known tool utilised by educators and businesses globally) was used to develop a prototype quiz called Basic NZ Ecology (see: <https://create.kahoot.it/share/basic-nz-ecology/06f04e04-ebed-4149-ba79-338900425101>).

The quiz consisted of 52 basic ecology questions, broadly encompassing NZ native flora, fauna, introduced pests, the environmental domains (moana, awa, repo, and ngahere), and atua (Māori gods) the environmental guardians of these domains. The addition of a scientific classification name (species) provided an opportunity to assess the potential complexity of new information that could be introduced.

The quiz was undertaken by groups of 4–6 students, and each group had a single device that was registered on the Kahoots portal. Groups were motivated to answer each question within a 20 second time limit to beat the other teams. One school requested to play the game several times, allowing familiarisation with the ecological concepts and endorsing memorisation of species, consequently winning the game.

Mobile gaming app ‘Eko’

The features from the Kahoots game that generated positive responses and correlated with previous studies were engagement, motivation, rewards systems, content mastery, and improved higher order thinking skills (Clark et al. 2009; Young et al. 2012). These features were integrated into a game format incorporating; graphic-rich content, a multitasking interface, fast and immediate feedback, and continuous activity, according to the recommendation of McClarty et al. (2012). The first iterations of the functionality and games aspects of the tool have been tested by a small case-study group of students (n = 4, 12–16 years old), and the feedback used to refine formatting and design. The second testing iteration was to observe content and engagement responsiveness. This case-study group of students (n = 8, 10–16 years old) provided feedback that was then incorporated into the platform before larger scale testing. The choice of species and imagery used was based on the



Figure 2. Relative frequency the largest size font reflects the frequency of word and its considered value: Values for the moana (sea) according to the three categories taiao ora (flourishing nature), whānau ora (thriving families) and mauri ora (the essence of vitality).

accessibility students have to the environment. Species that were unlikely to be encountered, e.g. rare or nocturnal birds such as matuku/Australasian bittern (*Botaurus poiciloptilus*), were not included. The species are identified in Māori, English, and by their scientific name.

Results and Discussion

Given the critical place of kaitiakitanga within Māori culture, and the commitment of Māori immersion schools to engage respectfully with, and have care and love for Papatūānuku (mother earth), the researchers had assumed before the study that students were taught basic ecological concepts and principles, i.e. NZ native flora, fauna, introduced pests, and environmental domains. This was not the case, as ecology is not a core subject within the New Zealand education system (Cowie et al. 2004; Matthewman et al. 2017). Through the interactive session's students revealed that they were unfamiliar with key ecological concepts, which aligns with reports by Stewart (2011) and Smith (2012) at a national level. Loss of social-ecological systems and the disconnection of people with their environment through 'extinction of experience' is a global concern (Miller 2005; Biggs et al. 2015; Soga et al. 2016b; Cox et al. 2018; Diaz et al. 2019).

Of particular concern to Māori is the loss among youth of mātauranga (knowledge) in this instance, around environment, i.e. traditional practices, waiata (songs), karakia (prayers or incantations), etc. These displacement concerns and cultural losses are a global phenomenon for indigenous cultures, for example in Japan where several 'extinction of experience' studies were conducted (Soga et al. 2016a; Soga et al. 2016b; Soga et al. 2016b), Australia with the Yolngu tribes of North East Arnhem Land (Petheram et al. 2010) and Walpole Island First Nations Canada (Beckford et al. 2010).

However, as environmental education is determined by each school (OECD 2017), there is compelling evidence that interaction with ecosystems provides multiple learning opportunities (Smith 2002; Smith et al. 2013) through both formal and informal transfer of knowledge. Lack of interaction with these environments is linked to a paucity of ecological knowledge (Louv 2008), a decrease in physical and psychological health (Cox & Gaston 2015; Soga et al. 2016b), a collective indifference to nature and its protection (Miller 2005).

The importance of contextualising learning that resonates with students is well established (Nation 1993; Kola-Olusanya 2005; Vandenbosch 2007). Although initial workshops with each school demonstrated that it was possible to apply the cultural freshwater monitoring method across different ecosystems, the absence of basic ecological literacy meant students had limited knowledge with which they could apply the tool. Surveys revealed that student's awareness and perceived value of the environment and the role of environmental sciences within it increased substantially after their wānanga experience (Fig. 3).

We observed that using gamification to teach youth ecological concepts led to rapid gains in knowledge because the game appealed to their sense of competition, and provided immediate feedback that encouraged high levels of formative assessment processes in their attempt to answer questions correctly. By exposing students to the concepts multiple times, they became familiar with them, and were able to recall them on later occasions. This is consistent with observations from

the Kahoots game trials and game-based learning reported by others (Hamari et al. 2016).

In this study, 72% of students indicated they wanted to continue playing the Eko game, demonstrating that the game positively resonated with the target audience. However, 21% of students surveyed found the game 'hard' with 11% of students specifying that they did not want to continue playing. Students' additional feedback on the game noted their motivations included the mental challenge, cited as 'using their brain' (17%), 'learning new things' (14%), and 'the challenge' (7%). A small number (3%) enjoyed competing against others (Fig. 4). Students cited that the theme of Tane Mahuta (level 1 – atua of the environmental domain Ngahere) was particularly appealing, as was the imagery.

It became evident that more research is required to understand student engagement levels and interaction, and the reasons why students remained engaged. Another consideration for future investigation is knowledge acquisition and retention from single game use to multiple interactions, and how this is transferred into application.

Trends from the survey data indicated that the challenge presented was critical in supporting development of a diverse range of skills such as problem solving, planning and critical thinking (Vandenbosch 2007).

Learning is subjective and specific to the individual and 65% of the students reported some degree of knowledge acquisition. Reported knowledge recall amongst the students was variable with 28% citing no recall, and 35% recalling at least 3 species from the potential 15 species which they were exposed to (Fig. 4). Further, a subsequent trial of the Eko game in a mainstream secondary school in the Bay of Plenty region noted the cross-cultural appeal of the game (e.g. to students identifying as Asian).

Students commented further that they could see career pathways for themselves in science because they could aspire to follow in the footsteps of the Māori subject experts and researchers with whom they had contact.

The core principles of this research, which were embedded in the Eko game were to connect people to people, and people to place by engaging students at their current skill base and building on that knowledge (Chawla et al. 2007; Kudryavtsev et al. 2012; Ballard et al. 2017). Numerous published reports describe the ability of digital platforms and gamification to engage children and youth in learning concepts, the use of these applications has been linked to an increase in environmental literacy and pro-environmental behaviours (Anderson 2010).

Intergenerational knowledge transfer through Māori subject experts, was a critical factor in enabling youth to engage with the environment. As has been reported by others (Chawla et al. 2007), interaction with gaming devices supports individualised learning at the pace of the student, thereby removing learning barriers and assisting students to achieve their best results (McClarty et al. 2012; Dorward et al. 2017). The Eko game was officially released as a bi-lingual resource in November 2019; the game can be accessed at www.eko.nz (and see Appendix S5 in Supplementary Materials).

Conclusion

This research highlighted that while 'extinction of experience' for youth is a critical issue globally, here in New Zealand through our indigenous culture we have frameworks and mechanisms which can be transferred into digital platforms

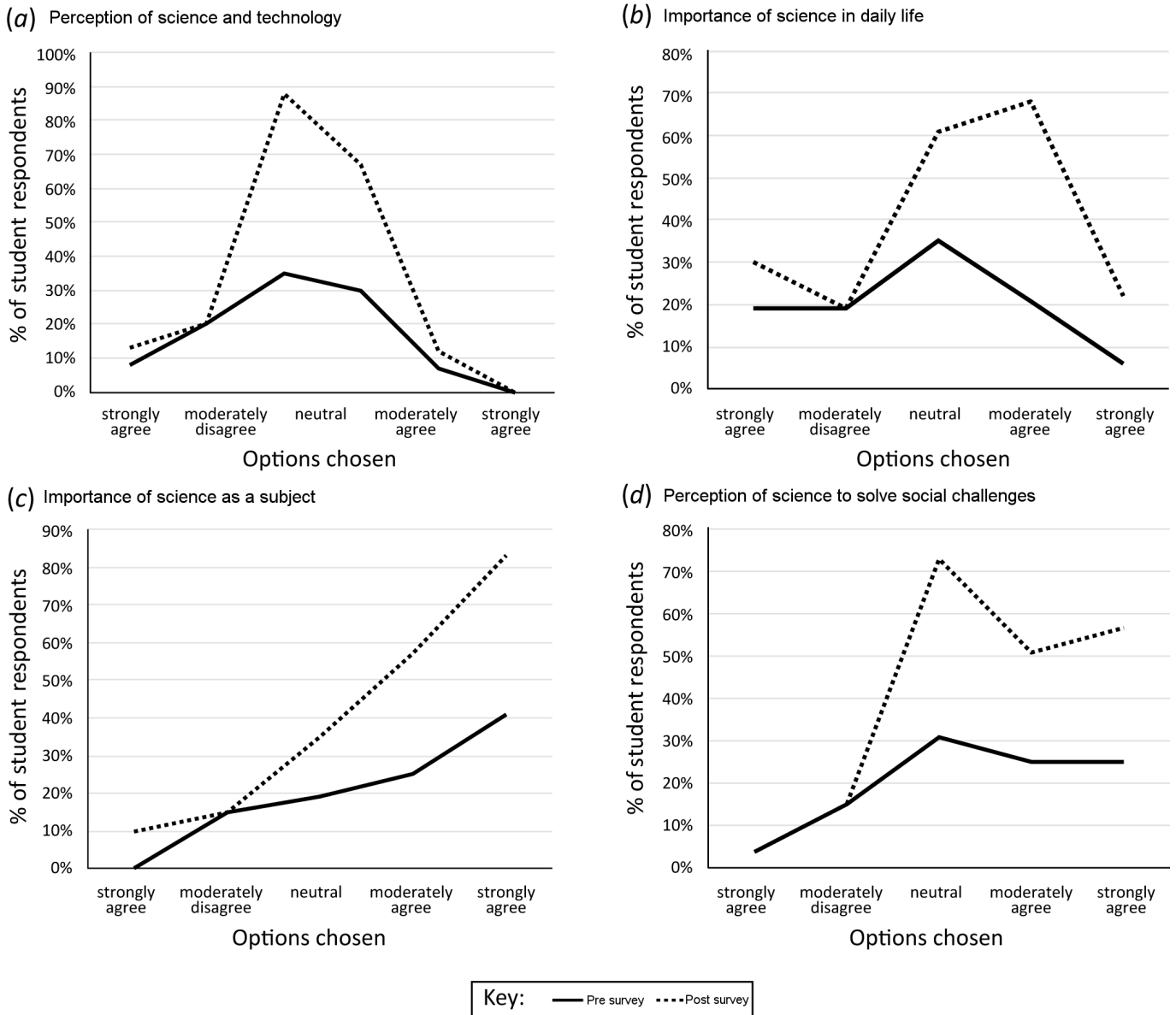


Figure 3. Selection of questions from pre- and post-project surveys. The contextualised experience the students engaged in as part of this program was the wānanga (total immersion learning experiences) and gamification platforms. Post survey data indicates the significant shift in students thinking about science and technology after the learning experiences: (a) Reflects the shift in how students perceive science and technology, (b) Students acknowledgement of how important science is within their daily life, (c) How students perceive the importance of science as a curriculum subject, and (d) Students perspective on how science can be used as a problem solving tool for societal challenges.

which mitigate the disconnection. Using the technological advancements of our time, we can still maintain the integrity of our cultural practices passed down from our ancestors. As kaitiaki, it is our responsibility to ensure that through the mediums we have today and associated technological advances that we maintain the transferal of our environmental knowledge to sustain our well-being physically, mentally and psychologically, this is emphasised and entrenched in our Māori world view. We believe that this integrated approach supports student's achievement, and increases interest in engagement, knowledge acquisition and pro-environmental behaviours from active participation in this programme.

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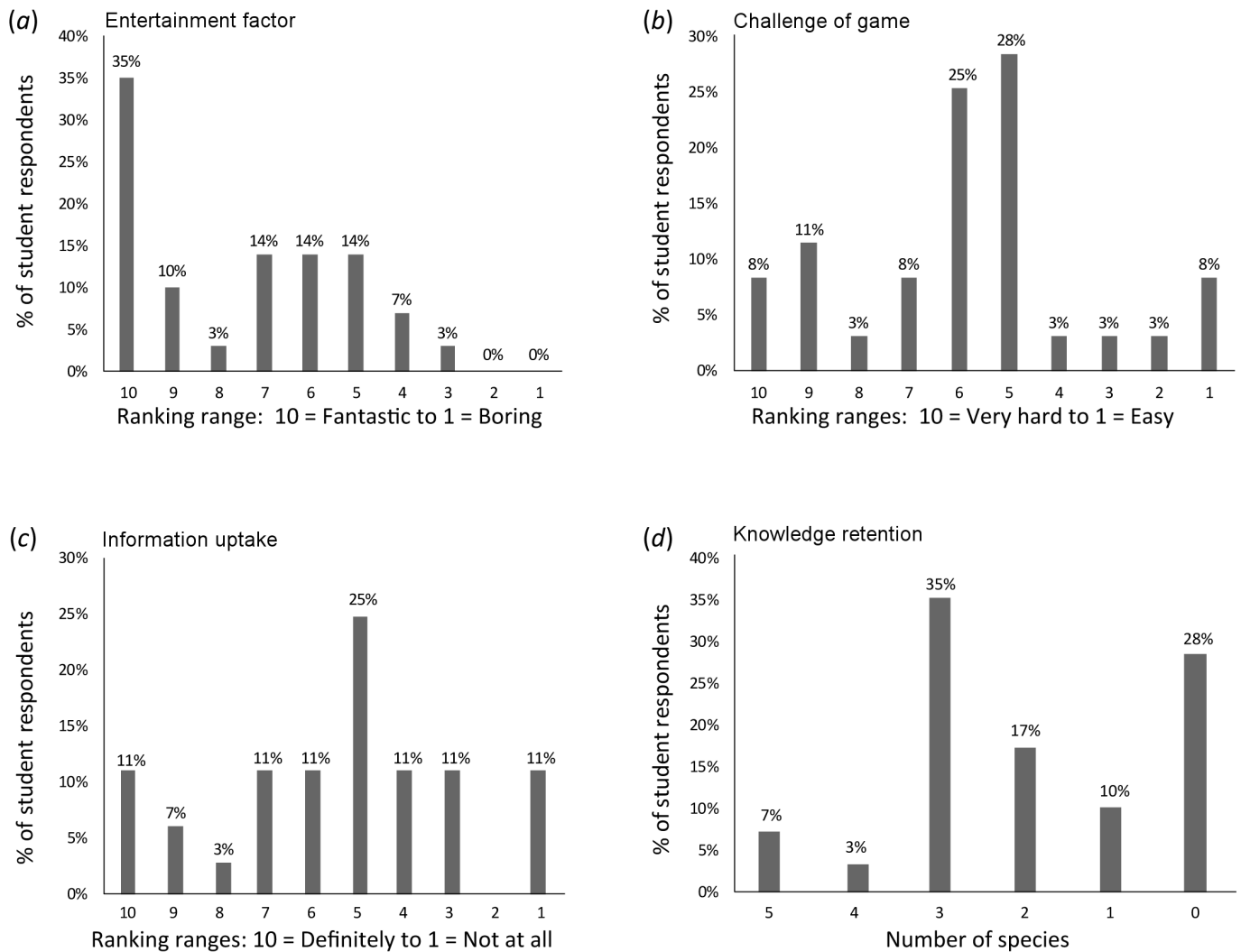


Figure 4. Gamification results from both wharekura, student's expressing their interest and knowledge acquisition from the Eko game. (a) Student responses to the entertainment factor of the game, 90% of students ranked it 5 (average) and above. (b) Responses of how challenging the students found the game 53% of students ranked it as an average challenge 5-6, with 31% ranking it hard to very hard. (c) Information uptake by students, 68% indicate 'average' to 'definite' knowledge acquisition. (d) Knowledge retention from first usage. 45% of students indicate new knowledge acquisition for 3 or more species.

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Supplementary material

Additional supporting information may be found in the supplementary material file for this article:

Appendix S1. Study participant information.

Appendix S2. Examples of ORID focused conversation questions asked to student to stimulate feedback about the moana.

Appendix S3. App design survey

Appendix S4. Eko game survey

Appendix S5. Eko game poster

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