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Indigenisation of conservation education in New Zealand

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Abstract. Indigenous Māori youth struggle to connect with science delivered in a Eurocentric model of education in Aotearoa, New Zealand. In transforming conservation biology through Indigenous perspectives, we asked whether Māori knowledge-based resources and traditional schooling (wānanga) methodologies increased the connection of Māori youth (rangatahi) to conservation science. We collaborated with a Māori environmental science body to run a culturally based environmental program (noho taiao) attended by 70 youth from three Māori-centric schools. We undertook surveys to assess baseline scientific understanding and to gauge how their understanding of the Māori-based conservation principles we introduced shifted over the course of the program. We developed a bilingual gaming app to introduce basic environmental concepts from both cultural perspectives, measuring its impact on knowledge retention for these students, and others at a Eurocentric school. Indigenous contexts for conservation learning markedly increased uptake of knowledge content, and enthusiasm for conservation concepts. After the program, Māori students reported that science was more accessible and relevant. Gaming as an educational medium was successful in engaging youth generally, but students primed by experiential learning from Indigenous perspectives had increased knowledge gained. Enabling rangatahi to explore place-based learning within a relevant cultural context allowed them to understand their duty of care to the environment (te taiao). Utilising Māori engagement mediums and mentors that resonate with youth are key to encouraging more Māori youth into conservation science. Therefore, empowering youth to draw from Indigenous ways of knowing, being and doing can create a step-change in science participation and leadership.

Keywords: Indigenous peoples, Indigenous youth, kaitiakitanga, kaupapa Māori, mātauranga, place-based education, traditional ecological knowledge.

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Introduction

'Ko au te Taiao, ko te taiao ko au',
I am the environment, the environment is me.
Traditional Māori proverb.

Despite recent advances, Indigenous Knowledge (IK) globally is rarely incorporated into education curricula (Michie 2015; Ezeanya-Esiobu 2019; Smith 2000), erroneously signalling to Indigenous students that non-Indigenous ways of knowing and doing are the only valid knowledge systems. This omission suggests to students that IK systems do not incorporate scientific thinking, and may lead Indigenous students to feel unwelcome in science classes (Fonua 2020). Indigenous students often fail to connect with science concepts and subjects because they are delivered through a non-indigenous lens that is not consistent with their own world views (Skamp and Preston 2020), and therefore tend not to pursue careers in the physical and natural sciences. However, Indigenous Peoples (IP) worldwide are stewards of more than 80% of the world's biodiversity (Sobrevila 2008; Garnett *et al.* 2018), with knowledge systems built on foundations that span millennia. These systems include environmental philosophies and practices as well as knowledge of ecosystem processes, species ecologies, and temporal and spatial environmental indicators (Moller *et al.* 2004; Berkes 2009; Wehi *et al.* 2020) and, as such, have a great deal to offer an education curriculum. IK embeds values that are centred on a kin relationship with nature, grounded in the physical and spiritual dimensions of whakapapa (codified knowledge that identifies

connections between human and non-human kin) (Hikuroa 2017; Wehi *et al.* 2020), which differs from non-indigenous-trained scientific approaches that weigh the value of nature according to, for example, ecosystem services or biophysical data (Watene and Yap 2015; Hikuroa 2017).

International policy acknowledges the key role that IP and expertise play in biodiversity conservation globally (Ens *et al.* 2016; UNEP-WCMC IUCN 2016; and others). However, many IPs, such as Māori in Aotearoa New Zealand (ANZ), have also endured substantial damage to cultural knowledge systems and practices, environmental relationships, identity and health because of colonisation (Manuelito 2005; Moewaka Barnes *et al.* 2019). In ANZ, European colonisation and settlement in the early 19th century led to the disconnection of many indigenous Māori families from ancestral lands, with land progressively alienated and fragmented since that time (see for example, the *New Zealand Settlements Act 1863*: Sinclair 2002; Wehi and Roa 2020). In the 20th century, fragmentation of rural Māori communities has continued, with disease, unemployment and other issues leading to the migration of many families from their tribal roots to new settlements in cities (Ryks *et al.* 2016). These issues have contributed to alienation from the natural world for youth in particular, sometimes called 'the extinction of experience' (Pyle 1993; Miller 2005; Soga and Gaston 2016). Although this phenomenon has largely been discussed in terms of urbanisation, for IPs we argue that the long-term effects of colonisation are even more important. Many IPs now lack access to traditional lands where stewardship practices associated with IK take place, and this alienation has been revisited through the legal system (see, for example, the *Foreshore and Seabed Act 2004*, *Burnt Land Act 1948*: Bockstael and Watene 2016; Wehi and Lord 2017; McAllister *et al.* 2019). As well, disconnection of youth from the environment can be accelerated by technological advancements (Barton 2012; Bryant 2013), although, conversely, technology can also be used for positive outcomes such as environmental learning (Kral 2010; Barnett *et al*. 2011; Reihana *et al.* 2019). Exploring how technology can work to support youth and IK is therefore vital. Revitalisation of cultural knowledge and practice is a pressing issue for Indigenous cultures to thrive, and for biodiversity to benefit from Indigenous stewardship.

A further issue is the pressing need for comanagement agreements over natural resources, now an imperative for tribes settling Treaty (Treaty of Waitangi 1840) grievances with the crown and its representatives, as these measures are seen as redress for the impact of colonisation on Māori. Tribal groups are seeking to grow internal capacity in environmental management, monitoring, decision making and legislative reform to embed Māori cultural values and knowledge systems. Yet, currently, few Māori are trained in science at tertiary institutes, resulting in under-representation of Māori scholars within these institutions, and elsewhere in environmental decision-making roles (Bockstael and Watene 2016; McAllister *et al.* 2019). With 41% of Māori being under 19 years old, and 74% living in urban areas (Statistics NZ 2018), a critical goal for this research is to transform conservation biology using Indigenous perspectives by increasing participation of Māori students in Eurocentric science education, and reconnecting these students with the science of their ancestors.

Intergenerational knowledge transfer is a crucial issue to combat the extinction of experience and maintain cultural vitality for IPs, and Indigenous youth in particular (Reihana *et al.* 2019; Walker *et al.* 2019). Knowledge transfer is the key conduit for cultural resilience and survival, not just for Māori but also for cultures worldwide from Ramah Navajo on Turtle Island (Manuelito 2005), to kānaka 'ōiwi in Hawai'i (Wilson and Kamanā 2011), to Sami (Todal 1998), to Quechua (Hornberger and King 1998). Because place-based knowledge is deeply embedded in Indigenous environmental ways of knowing, developing environmental programs based on these knowledge systems naturally, become instrumental for reconnection and advancement of proenvironmental behaviours among youth. To address the decline of ecological literacy apparent in youth globally, marae (Māori community-centred gathering spaces) and community-based programs have developed over the last two decades with the intent of transforming conservation biology from a Māori perspective (Smith 2000; Reihana *et al.* 2019; Walker *et al.* 2019). The central premise of these programs is to elevate IK, or mātauranga, as a step change to redress for IPs by challenging the prevailing colonial ideology of science as a Eurocentric construct (Smith 2000; Smith 2013; Hikuroa 2017).

Our first key aim was to investigate whether traditional learning practices (wānanga) and IK could increase engagement with, and knowledge gains in, conservation science concepts. To do this, we partnered with a community Māori immersion education foundation to run a noho taiao (a culturally based environmental program) with three Māori-kaupapa based learning schools, and assessed the relevance and accessibility of the program content for student participants. Secondly, we examined the potential to adopt technological resources to increase knowledge retention, developing a bilingual educational gaming app to introduce basic environmental concepts from both Māori and New Zealand European cultural views.

Materials and Methods

Noho taiao environmental program

Noho taiao is an iwi (tribal) driven initiative that began in 2009 within Te Rarawa tribal area (Moewaka Barnes *et al.* 2019). The program aims to reconnect rangatahi (youth) to their various iwi marae (tribal meeting places), by providing a cultural space for youth to reconnect, strengthen and grow cultural confidence through engagement with, for, and in, the range of environments within their tribal areas. It also aims to familiarise rangatahi with a range of environmental cultural challenges and initiatives; in the Te Hiku, Northland noho taiao program, for example, it is a priority to raise student understanding of kaitiakitanga practices, and show students how they might be able to contribute to their iwi (tribe) and hapū (community units) in the future. A second aim is to increase the number of Te Hiku rangatahi pursuing career pathways in the sciences, environmental sustainability, technology and business. During the marae immersion program, school hours did not apply. This is typical for immersion programs of this type in ANZ.

The noho taiao is a kaupapa (philosophy) Māori led initiative ('by Māori for Māori') based on Māori principles and methodologies; in this instance we use it as an 'inclusive' term that describes a Māori way of thinking and doing things that feels

culturally appropriate and which takes seriously our [Māori] aspirations. The underlying Pūnaha Akoako, a resource developed by Te Aho Tū Roa, was a methodology used for noho taiao, which is centred on five key notions which outlay a pathway learning journey (Supplementary material, Fig. S1, Punaha Akoako resource): (1) Nō hea tātou? (Where have we come from?), (2) Kei hea tātou ināianei? (Where are we now?) and this section is broken down into three main focus areas: (i) Takahia te ara tūhura (Follow the path of discovery); (ii) Ruku hōhonu (Diving deeper); (iii) Rangahaua (Research it), (3) Me ahu pēhea? (Where do we want to go?), (4) Whakatinanatanga (Implementation – put it into action) and (5) Pūmahara (Reflections). This process provides facilitators/teachers with a culturally embedded framework used as a guideline with open-ended questions designed to draw out and scaffold genuine student-driven/cocreated learning and teaching to occur. Further framework concepts are explained in Supplementary Material – noho taiao framework extension.

Participating schools

We tested a new science engagement program, called noho taiao, with two schools in two regions of the North Island, ANZ (Fig. 1). We worked with Māori language immersion school Te Wharekura o Maniapoto (TWKoM), in the Waikato region in 2018, and in 2019 we included an iwi-led (tribally-led) Māori immersion school at Te Kura Taumata o Panguru (TKToP), Northland. We also conducted an abridged version of the noho taiao program, which included a field trip into the neighbouring wetland area, with Māori immersion school Te Wharekura o Rakaumanga (TWKoR) in the Waikato region, within the

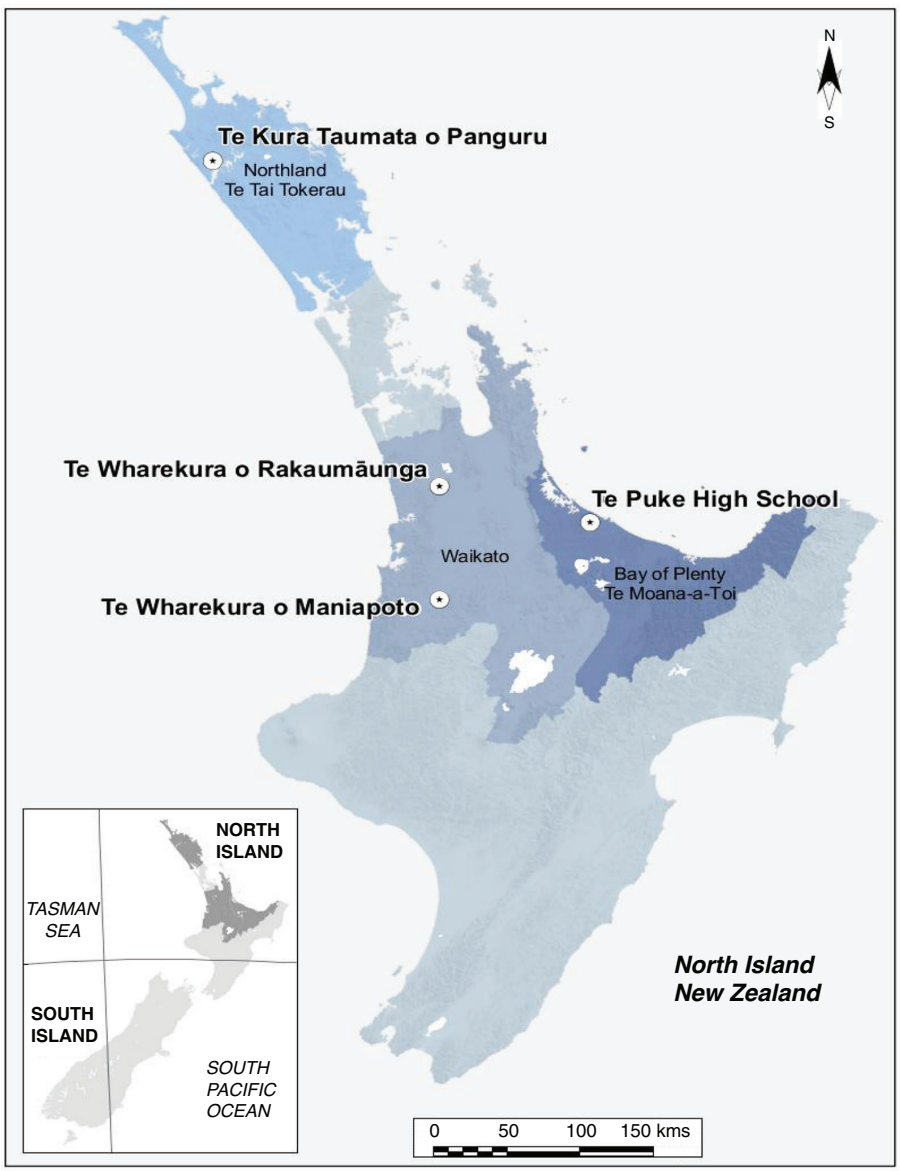

Fig. 1. Location of schools and the regions in which they are located in the North Island, New Zealand.

normal school curriculum. TWKoR is a leading New Zealand kura kaupapa (total immersion Māori language school) located in Huntly, in the Waikato region (Fig. 1). Students are aged from 14 to 17 years, with most being of Māori and Pacific Island descent. Students who completed the normal school curriculum environmental activities (TWKoR) participated in class workshops (housed inside) and a field trip to their local wetlands, as determined by the Eurocentric education curriculum (see Reihana *et al.* 2019 for full details). These schools sought the opportunity to activate kaitiakitanga (that is, to become agents of action in preserving, conserving and protecting the natural resources with which we coexist: (Marsden 1992; Royal 2003)) and mobilise mātauranga (Māori knowledge systems) in their students by participating in noho taiao in their regions. In addition, students from a Eurocentric curriculum secondary school, Te Puke High School (TPHS) in the Bay of Plenty (Fig. 1), trialled the 'Eko' game but did not participate in the noho taiao program or the curriculum workshops. TPHS students are aged from 14 to 17 years, with an ethnically diverse enrolment, including European, Māori, Pacific Island, Chinese and Indian students.

Gaming

Students from all schools trialled the 'Eko' game, including the Eurocentric school (TPHS). Eko (https://eko.nz) is a free, web based, basic New Zealand ecology game that was developed and trialled in 2018 and 2019. The game introduces students to basic ecology principles from a Eurocentric and Māori perspective. Further details and the entire program description are published in Reihana *et al.* (2019).

Ethics

Ethical approval was received from the Manaaki Whenua Social Ethics Committee. We also completed all required health and safety requirements, including risk assessment management plans, for program activities. School parents received program information and provided permission for all youth participation.

School surveys

To assess the effectiveness of the noho taiao program, and overall changes in student engagement, we asked students at all schools to complete surveys before and after the noho taiao program (Table S1, Fig. 2). Students were asked to what degree on a 5-point scale (1 = strongly disagree, … 5 = strongly agree) they agreed with statements on science and the environment (see Reihana *et al.* 2019 for full survey details). Students who participated in the noho taiao program, in an environmental program in a Eurocentric curriculum, or in no environmental program in a Eurocentric curriculum completed the pre- and post-noho taiao surveys. All students who completed these pre- and post-noho taiao surveys also participated in the Eko computer game (Fig. 2).

An additional survey was designed for the Eko game to observe the different aspects of learning potential that the game offered and was administered to students after playing the game. There was no pre-Eko game survey. Most questions for the Eko game survey were on a 10-point scale (e.g. 1 = did not learn anything, … 10 = learned a lot). Full survey questionnaires are provided in Reihana *et al.* (2019).

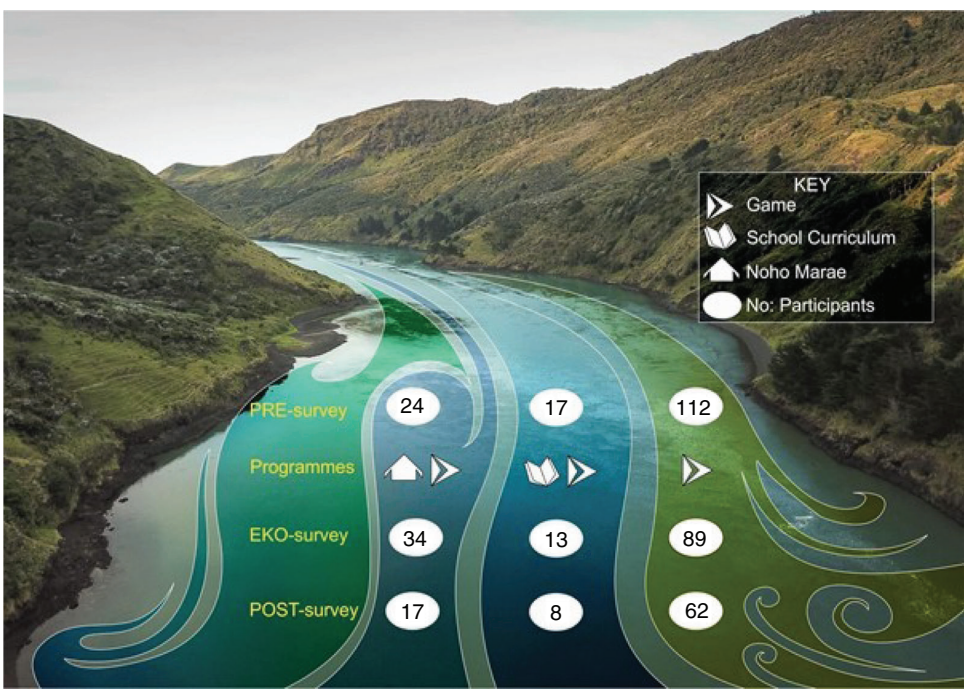

Fig. 2. Infographic based on the theme of the noho taiao (marae based environmental program) 'ki uta ki tai', 'mountains to the sea'. The tableau represents the total number of participants in each of the program variations. These numbers reflect survey respondents only from the total participant pools; for the complete data set, see Table S1.

Analysis

Survey data from the noho taiao program and 'Eko' game were analysed using two different statistical methods to assess the effectiveness of the program and game. For both analyses we define our 'intervention' and 'control' groups as follows:

(1) Analysis of the 'noho taiao program' means that the 'intervention' group was the students who participated in the noho taiao program and the 'control' group was the students who went through the Eurocentric curriculum either with or without an environmental component.
(2) Analysis of 'any environmental program' means that the 'intervention' group was the students who participated in the noho taiao program or students who went through the Eurocentric curriculum with an environmental component. The 'control' group in this analysis was students who went through the Eurocentric curriculum without an environmental component.

To assess the effectiveness of the noho taiao program, we used a difference-in-differences statistical approach (Fig. S2). We examined the change in environmental engagement that could be attributed to the noho taiao program by comparing the average change in responses in the pre- and post-noho taiao program surveys between 'control' and 'intervention' groups using a difference-in-differences regression method. We used the difference-in-differences regression method to also assess the effect of 'any environmental program' as defined above. A summary of statistical demographic data (Tables S2, S3), technical description and detailed results of this method can be found in the Supplementary Material. We used equality of means *t*-tests to investigate differences in the perceived impacts from playing the 'Eko' game for students in the 'intervention' groups versus the 'control' groups as defined above. Survey data were processed and analysed using the statistical analysis software Stata (www.stata.com). Results were tested for statistical significance at the 90%, 95% and 99% confidence thresholds, and statistical significance is noted where applicable.

The value of observational data provided from the students reveals the principles that resonated strongest from the program. A carefully considered thematic approach was used to cluster the most frequent and similar responses into key themes. A thematic analysis based on Clarke and Braun (2013) was used to articulate high level summations of their responses.

The mixed methodology analysis presented here provides an experiential narrative of the noho taiao program and the ability for the digital resource 'Eko' to work towards supporting a kaupapa Māori indigenisation of biodiversity conservation education in ANZ.

Results

Quantitative demographics

Overall, the average age of student participants was 14 years. Approximately half identified as female (47%), half as male (48.35%), and a small proportion identified as gender diverse (4.66%, see Tables S2 and S3 for full details). More students in the noho taiao group identified as male (53%). Nearly all students in the noho taiao group were of Māori or Pacific Island descent (93.9%), whereas 42.6% of students who went through the Eurocentric curriculum (with and without an environmental program) were of Māori or Pacific Island descent and 34.3% of students who went through the Eurocentric curriculum with no environmental program were of Māori or Pacific Island descent.

Noho taiao program assessment

Before the noho taiao program, 25% of students who attended the noho taiao program ('intervention') moderately or strongly agreed that 'Science is often among the favourite subjects at school' compared with 36.4% of students in the Eurocentric curriculum ('control'; $\beta = -11.4\%$, $t(238) = -1.16$, $P < 0.25$, Table S4) (Fig. 3). After the noho taiao program took place, 36.7% of students in the control group moderately or strongly agreed with the statement, a 0.3% increase from before the program ($t(238) = 0.05$, $P < 0.96$, Table S4), and 71% of students in the intervention group moderately or strongly agreed with the statement, a 46% increase from before the noho taiao program ($t(39) = -3.17$, $P < 0.003$). Comparing the difference among groups ('intervention' versus 'control') over time (pre- versus post-program), 45% of the increase in likelihood of treated students saying they moderately or strongly agreed with the statement can be attributed to going through the noho taiao program ($t(238) = 2.82$, $P < 0.005$, Table S4).

We also test the effect of participating in any environmental program (noho taiao or Eurocentric with an environmental component) compared with not being exposed to any environmental program. Before the noho taiao program took place, 29% of students who participated in any environmental program ('intervention') moderately or strongly agreed with the statement that 'Science is often among the favourite subjects at school' compared with 36.6% of students in the Eurocentric curriculum without an environmental component ('control') who moderately or strongly agreed with that statement ($\beta = -7.3\%$, $t(238) = -0.86$, $P < 0.39$, Table S5). After the noho taiao program was completed, 38.3% of students in the control group moderately or strongly agreed with that statement, a 1.7% increase from before the program ($t(238) = 0.22$, $P < 0.83$, Table S5). Moreover, 56% of students in the intervention group moderately or strongly agreed with that statement, a 27% increase from before the noho taiao program was conducted ($t(64) = -2.2$, $P < 0.03$). When we compared the difference among groups ('intervention' versus 'control') over time (pre- versus post-program), 25% of the increase in likelihood of students saying they moderately or strongly agreed with the statement can be attributed to the noho taiao program ($t(238) = 1.71$, $P < 0.09$, Table S5).

Key comments made by students in the reflection workshops are shown in Table 1.

Eko gaming

Students who received any form of environmental program (either noho taiao or the environmental program in the Eurocentric curriculum) thought that they learnt more from the Eko game than students who did not participate in any environmental program (5.9 versus 4.0 out of 10, $t(133) = -3.72$, $P < 0.01$) (Fig. S3). Students who attended the noho taiao program also thought that they learnt more from the Eko game than students who went through in the Eurocentric curriculum (6.2 versus 4.2

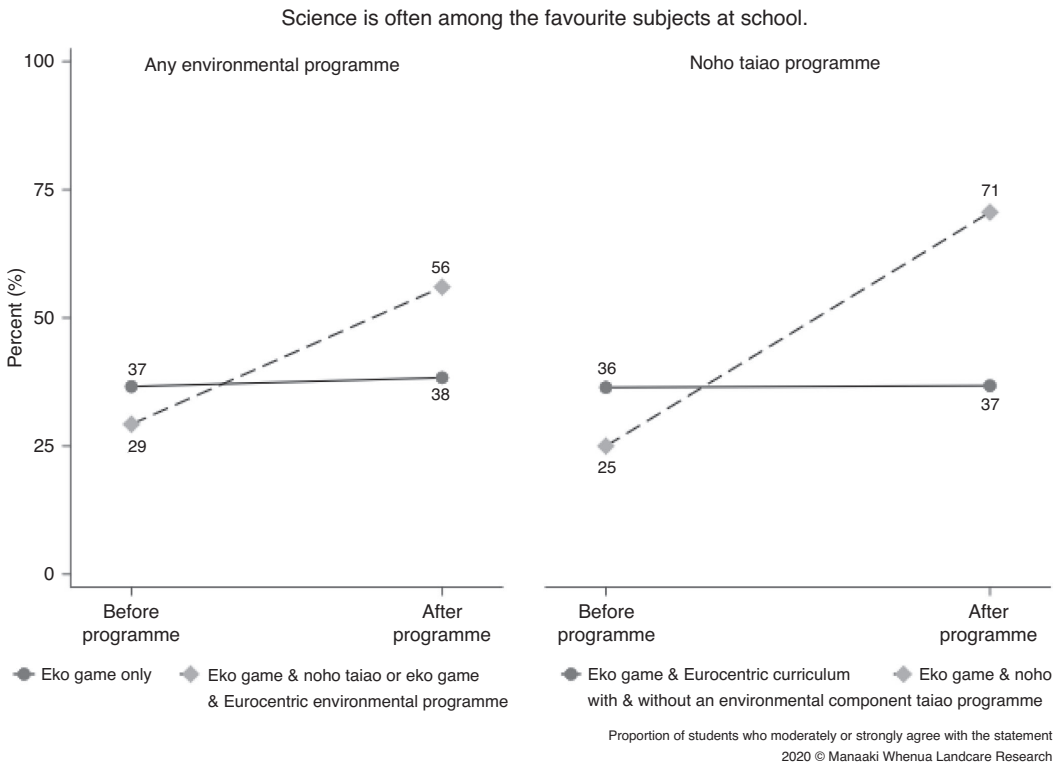

Fig. 3. The average proportion of students who moderately or strongly agree with the statement 'Science is often among the favourite subjects at school' in the control groups (represented by the solid line and circle in both panels) versus intervention groups (represented by the dash line and diamond in both panels) before and after going through an environmental program. The control group in the left panel is defined as only having participated in the Eko game. The intervention group in the left panel is defined as having participated in the Eko game and either the Eurocentric environmental curriculum or the noho taiao program. The control group in the right panel is defined as either only having participated in the Eko game or having participated in the Eko game and the Eurocentric environmental curriculum. The intervention group in the right panel is defined as having participated in the Eko game and the noho taiao program.

Table 1. Student identification of critical concepts from daily reflection in the noho taiao program, with examples of both processes and knowledge associations of biological conservation principles

Key concept/value	Examples of process	Knowledge that emerged
Kaitiakitanga	Kia tū mō te whenua, āra, tiakina te whenua hoki (to stand for the land and protect it)	Kia ū ki te kaupapa (to be consistent for the cause)
	Clean our water, get rid of pests and weeds, and send them back where they came from. Plant more	What is required in protecting the land
	Make plastic illegal, so no packaging. Find kauri not infected and plant them in multitudes	Understanding of anthropogenic impacts, incursions and diseases
	Exercise more rāhui (ban on use) to allow kaimoana (seafood) to grow and nurture	Resource management, traditional methods of legacy thinking
	Kia pono marika ki te whakamahi kōrero ki ōu mokopuna ki te tiakina nga whenua Me ngā rākau hoki. Na reira ki akona kua I ōu whānau me nga iwi take take	Resource management, traditional methods of sustainability and intergenerational knowledge sharing
Key values of importance	Wairua (spiritual), ihi (awe inspiring, spiritual power of place) happy, mana (effectual authority, authoritative, influence), karearoto (emotions), feeling, breath-taking, proud	Values that resonated with the youth, that they identified as guiding principles for their actioning of environmental conservation

out of 10, $t(133) = -3.61$, $P < 0.01$) (Fig. S4). Noho taiao school students were also more likely to say they would like to keep playing the Eko game than students who went through in the Eurocentric curriculum (65% versus 41% who said 'yes', $t(131) = -2.61$, $P < 0.0102$) (Fig. S5), (the continued desire to play here correlates with studies verifying increased

participation and uptake of knowledge, two key conservation education principles: Lieberman and Hoody 1998; Emekauwa and Williams 2004; Turner 2004). There was also a difference in the desire to keep playing between students who participated in any environmental program and those who received no environmental program prior to the game (67% said 'yes' versus 36% who said 'yes', $t(131) = -3.71$, $P < 0.01$) (Fig. S6).

Students who participated in any environmental program reported that the Eko game was, on average, more entertaining than did students who did not participate in any environmental program (7.9 versus 6.8 out of 10, $t(133) = -2.59$, $P < 0.011$) (Fig. S7). In addition, noho taiao students reported that the Eko game was, on average, more entertaining than did students who went through the Eurocentric curriculum (8.1 versus 6.8 out of 10, $t(133) = -2.63$, $P < 0.01$) (Fig. S8).

Students who attended schools that participated in any environmental program were more likely to retain knowledge of species after playing the Eko game (recalled an average of 2.1 species), than students who went through the Eurocentric curriculum (recalled an average of 0.9 species) (61% recalled at least 1 species versus 42%, $t(109) = -2.03$, $P < 0.045$) (Fig. S9). Students who attended the noho taiao program were more likely to say they remembered at least one species after playing the Eko game than students who did not experience place-based learning outside the classroom (68% versus 42%, $t(109) = -2.60$, $P < 0.011$) (Fig. S10).

Qualitative workshop data

During the programs, we facilitated group workshop sessions so that we could collect individual insights and feedback contributed as a group. We first asked TWKoM and TWKoR students 'What does the health of the environment look like for you?'. We have categorised this feedback as Program 1. Program 2 workshop sessions were conducted with TKToP students who were asked 'What does kaitiakitanga look like to you?'. The responses were then clustered into the emergent themes (Table 2).

Table 2. Emergent theme clusters based on students' statements from the two workshop programs
Statements capture students' responses to cultural conservation programs, their conservation knowledge gains and increased awareness of conservation biology issues

Theme	Program	Statements
Responsibility: kaitiakitanga in action	1	(1) Clean up rubbish (2) Clean the water (3) Look after sea creatures, etc
	2	(1) Get rid of pests (2) Kill the pigs, kill the possums, stoats, rats, etc (3) People being responsible animal lovers – pets speyed (4) Major decreases of predators and disease (5) Kia tū mō te whenua āra, Tiakina te whenua hoki (to stand for the land, and protect it)
Reciprocity: Tuakana–teina; learning and teaching	1	(1) Educate others (2) Positive vibes (3) Show leadership (4) Be safe at all times (5) Do the best you can
	2	(1) More wānanga on our taiao (like this) and the changes happening in it (2) Put a rāhui on some parts of the Warawara (3) To keep animals and trees alive (4) More rāhui in place to allow the kaimoana to grow and nurture (5) Healthy plants growing, people using plants for kai and rongoā
Legacy: what will be protected in the future	1	(1) The treaty of Waitangi (2) Enforce different laws (3) Help (4) Fight (5) Educate (6) Be humble (7) Strength
	2	(1) More Māori scientists (2) Kia ū ki te kaupapa (to be consistent for the cause) (3) Us being leaders for our moko (4) Upholding the noho taiao legacy (5) Seeing our mokos upholding our nga kaitiakitanga nga legacy (6) I hope my mokos find a cure for kauri dieback (7) Our whakāro and stories are still being told to this day

Responsibility – kaitiakitanga in action

Students understood that being kaitiaki meant they were agents who acted as protectors, caretakers and conservationists of the environment in mitigating negative environmental impacts such as pollution, pest invasion and disease. Students were very conscious of positive environmental actions such as pest eradication, cleaning up and managing pollution inputs and humans, and being responsible for their behaviours. Specifically, biodiversity and management across scale gradients was considered and approached through the lens of kaitiakitanga. These empathies are reflected in the student statements (Table 1). Students' responses were imbued with the relational aspects of protection, and caretaking core principles of sustainability from a Māori perspective.

Reciprocity – tuakana-teina (learning and teaching)

The enduring learning-teaching reciprocity between older and younger youths under the theme of Tuakana-Teina, was an understanding of reciprocity that featured repeatedly. A second key understanding that featured consistently was rāhui (where no collecting or gathering of resources is permissible or use of a space) which reinforces Māori philosophies of allowing the earth to rest and/or recover after completion of an event or harvest. Rāhui is a key sustainability principle of reciprocation between the earth and humans. Again, the kaupapa Māori lens strongly featured in the students' responses (Table 2).

Legacy – what will be protected in the future

The third theme we identified from the workshops was one of legacy. As with responsibility and reciprocity, students identified the legacy for future generations as a critical consideration. This was strongly signalled in the uptake of the kaupapa Māori lens embedded in the programs. Their concern for future generations and the intergenerational knowledge transfer legacy that was being passed to them, the importance of this responsibility, and their duty to imbue that in future generations, was potently captured in their responses (Table 2).

Discussion

> *"The best teachers are those who show you where to look, but don't tell you what to see"*
>
> *Alexandra K Trenfor*

The survey results clearly indicate that both the noho taiao program and the Eko game had positive benefits for students, consistent with other indigenous and gamification studies (Kral 2010; Barnett *et al.* 2011; Reihana *et al.* 2019). The cumulative benefits of the noho taiao program and game were emphasised in the students' enjoyment and increased participation. The increase in student enthusiasm for science at school after participation in the noho taiao program strongly suggests that delivering science concepts within a cultural context increases engagement of Māori youth (Reihana *et al.* 2019; Walker *et al.* 2019). Our data show that although participation in any of the environmental programs presented to students led to gains in student understanding, the results were driven by the noho taiao experience by further enabling student engagement and leading to enhanced environmental understanding (Wilson and Kamanā 2011; Moewaka Barnes *et al.* 2019; Reihana *et al.* 2019).

For Māori, marae place-based learning in their environment is key to the fundamental organisation system known as whakapapa (Hikuroa 2017; Moewaka Barnes *et al.* 2019; Wehi and Roa 2020). The noho taiao experience provides context for a Māori worldview and incorporates Māori knowledge and values so that students can interpret this in relation to their local environment (Whyte 2017; Moewaka Barnes *et al.* 2019; Reihana *et al.* 2019).

Our research revealed significant positive trends from students in the noho taiao program and after using the Eko game that correspond with principles of conservation education. These four key principles seek to measure student attitude, behaviour, knowledge increase, and participation (Kellert and Wilson 1993; Al-Naqbi and Alshannag 2018; Braun and Dierkes 2019). For example, knowledge retention after playing the Eko game among students who went through the noho taiao program was significantly higher (68% remembered at least one species) than among students who did not participate in the program (42%). Noho taiao students also felt that they learnt more from the Eko game than students who did not experience this place-based learning outside the classroom. Participation and attitude towards what was learnt on the program was also higher among noho taiao students: 67% of students who experienced the noho taiao program wanted to continue playing the game versus 36% of students who were not in the noho taiao program. Although long-term outcomes are unknown, the indicators of increased student knowledge and interest in both game participation and curriculum science that we demonstrate here align with desired outcomes in conservation education (Powell and Ham 2008; Braun and Dierkes 2017; Braun *et al.* 2018).

In the students' reflections (Table 1), the high-level key values of significance have relational connections to the environment such as *wairua*, a spiritual dimension of mutual wellness between their spiritual, physical selves and place. This includes *ihi*, the sense of awe or excitement of, or the thrill or spiritual power those places evoke by being in them, as well as *karearoto,* the emotional connection that these environments conjure and their inherent linkages to past ancestors, histories and stories (Hikuroa 2017; Moewaka Barnes *et al.* 2019; Wehi and Roa 2020). Other key values are *mana*, reflecting the strength of these genealogical connections which is also embedded in '*whakamahi kōrero ki ōu mokopuna*'. This highlights the need to speak of the action of this work to their grandchildren, imparting the importance of sharing this knowledge intergenerationally (Hikuroa 2017; Moewaka Barnes *et al.* 2019; Wehi and Roa 2020).

Noho taiao acknowledges mātauranga and science as their own knowledge systems that operate in parallel, each with their own autonomy and validity. Through these kinds of opportunities we offer the students the richness of both worlds while maintaining the strength of a kaupapa Māori lens and what this can offer in biodiversity conservation (Mane 2009; Whyte 2017). By centring place, and our connections to it, at the heart of the education program, students can learn about their own connections to place and land, and therefore about their own identity as Māori, and connections to each other (Mane 2009;

Moewaka Barnes *et al.* 2019; Walker *et al.* 2019; Wehi and Roa 2020). This richness of experience cannot be replicated in a conventional classroom environment. Recognition that tūpuna were competent scientists with expert place-based knowledge about their environment was a key insight for students, from Table 1 '*kia tū mō te whenua, āra, tiakina te whenua hoki*' (to stand for the land and protect it). In addition, the presence of mentors in a tuakana-teina system of kaupapa Māori knowledge transmission (a reciprocal learning relationship between older and younger people) meant that students were able to see career pathways for themselves. Studies on the benefits of older teenagers as teachers of younger students about environmental sensitivity and behavioural change have consistently reported positive gains from such relationships (Madruga and da Silveria 2003; Rawlings and Wilson 2013; Hiha 2015). These aspects of the noho taiao approach use Indigenous philosophies and frameworks, and thus transform conservation education, enabling students to understand that both knowledge systems are valid, offering an equitable opportunity to participate in science-based domains (Whyte 2017).

The desire of students to engage in further science-based learning in the Eko game was enhanced by priming through delivery of an environmental program *per se*, and this was significantly greater when students participated in the marae place-based noho taiao experience. This demonstrates that the noho taiao experience delivered on the objective of the provider, Te Aho Tū Roa, to engage youth who acknowledged the value of their cultural connections and places to support their role as kaitiaki and kaimahi taiao (workers for the environment).

Students from the noho taiao program reported the highest enthusiasm for scientific study and the perception that science can offer future solutions. Another key insight for students was the understanding that mātauranga is dynamic and evolving so that it can keep pace with their changing reality, '*ki akona kua I ōu whānau me nga iwi take take*' (learning from your family the issues that are important to our tribes) and that iwi and hapū are using kaitiakitanga in the modern world. These understandings are important to secure the intergenerational approach that is required to realise environmental restoration initiatives and preserve cultural resilience in this contemporary context.

Data from the surveys conducted before and after the noho taiao program revealed that students had different perceptions of the impact of playing the Eko game on their engagement with the environment. Eko gaming was utilised to facilitate students' learning, but its effects differed based on how the students were primed by learning experiences prior to the game (i.e. noho taiao program, environmental program within the Eurocentric curriculum, or no environmental program within the Eurocentric curriculum). It has been noted elsewhere that the addition of technology can highlight the overall suite of experiential and contextualised actions, and increase ecological literacy (Barnett *et al.* 2011; Bryant 2013; Reihana *et al.* 2019).

That all of the students in the noho taiao program were of Māori and/or Pacific Island ethnicity compared with just 34% of the students in the other groups (those who went through a Eurocentric curriculum structure), may have contributed to the observed response to the game. Given that 53% of students in the noho taiao group were male, it is possible that the observed impacts of the noho taiao experience on response to the Eko game may reflect gender-based differences in the response of students to game-based learning (Tsai 2017). Expansion of this pilot program to include gender-balanced groups at a range of Eurocentric and Māori immersion schools would be useful.

In the current research, we were unable to compare regional responses to the program that might reflect specific iwi or community concerns and styles of learning. Reflections on Whakatinanatanga (Implementation – put it into action) and Pūmahara (reflections) are also absent from this study as not all participants have completed these sections of the program. Future work aims to extend the number of schools participating in the noho taiao program across a range of regions, so we can tease out some of these nuances. Despite these limitations, it is clear, overall, that students who participated in the experiential and contextualised learning program based on our kaupapa Māori praxis responded more positively than students who learnt within the Eurocentric curriculum regime or did not experience the noho taiao program.

Conclusion

Our research shows that incorporating cultural worldviews and knowledge systems makes conservation science concepts relevant and accessible for Indigenous Māori students. These principles are likely to apply to other IP who have suffered similar cultural assimilation. This in itself is transformative for facilitating their engagement with the environment. We provide compelling evidence that Māori students resonate better with science when the program is centred on IK and processes and reflects their own cultural understanding of knowing and being.

A noho taiao format increases student enthusiasm for environmental concepts, motivation to interact further with the environment, and knowledge uptake, beyond that achieved by an environmental program housed within a mainstream European cultural-based curriculum. This educational shift transforms not only how we are educating our youth, but how we are enacting conservation biology from an Indigenous perspective in the environment. The increasing presence of iwi kaitiaki, is proof of this transformative prescience being heralded here nationally.

The value placed on intergenerational knowledge, and of weaving ancestral science with new discoveries, is centred around reciprocity and responsibility. These types of conservation programs place future generations in a resilient and enduring conservation literacy standing. Delivery in cultural spaces supports both the participation and leadership of IP in protection of biodiversity. Inclusion of a gaming app to reinforce learning helped facilitate student engagement by utilising a medium that resonates with the target audience and was most effective when students had been primed by some form of environmental program. Undertaking conservation biology through a Māori lens ensures our cultural resilience, in our environmental practices such as kaitiakitanga. It is through marae-based programs that Māori have begun to disseminate their own conservation biology, in resistance to colonisation, thus transforming conservation biology in new and innovative ways.

Glossary

Au Warawara – name of the forest in Northland
Hapū – subtribe
Ihi – awe inspiring, spiritual power of a place
Iwi – tribe
Kai – food
Kaimahi – worker, labourer
Kaimoana – seafood
Kaitiaki – Māori resource manager
Kaitiakitanga – the enacting of Māori resource manager
Karearoto – emotional connections
Kaupapa – Māori ideology, Māori based
Korero – language, conversation
Mana – prestige, status
Manaaki Te Awanui – name of a pan-tribal research entity in Bay of Plenty
Marae – Māori community centred gathering space
Mātauranga – Māori knowledge
Moko, mokopuna – grandchild, grandchildren
Nga – multiple
Noho taiao – marae based overnight workshops
Pūmahara – memory, reflection
Pūnaha Akoako – Māori based framework
Rangatahi – youth
Rāhui – restricted, temporary, or regulated access to resources
Rongoā – Māori medicine
Taiao – environment
Te Aho Tū Roa – name of Māori environmental education entity
Teina – younger sibling, same sex
Te Hiku – name of Northland region
Te Kura Taumata o Panguru – the learning platform of Panguru (name of area)
Te Puke – name of place in New Zealand
Te Rarawa – North Island tribe
Te Taiao – the environment
Te Whare Kura o Maniapoto – the learning house of Maniapoto (Tribal name)
Te Whare Kura o Rakaumaunga – the learning house of Rakaumanga (Tribal name)
Tuakana – elder sibling, same sex
Tupuna – ancestor
Wānanga – classes, course, institute
Wairua – spirit, soul, spiritual dimension
Wehi – fear, awe or respect for a place
Whakapapa – codified knowledge systems that identifies relationship connections between humans and non-human kin
Whakamahi – use, operate
Whakāro – to think, plan, consider, decide
Whakatinanatanga – implementation

Conflicts of Interest

The authors declare no conflicts of interest.

Images

All images used in this publication were commissioned specifically for this publication. The location map describes the regions and locations of the participant schools involved. The infographic photograph is an original stock photo taken of the Au Warawara mountains and riverway supplied by Te Rarawa artist Richard Murray. All other images were created in the www.stata.com software and represent the statistical analyses completed on this project.

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