Envisioning student possible selves in science: Addressing “plant blindness” through place-based education

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Abstract

This project aims to develop primary, intermediate, and high school students' sense of place and science-related possible selves through local curriculum units that focus on plants. We chose plants because, compared with animals, they are often overlooked (hence the phenomenon of "plant blindness") in their part in realising many sustainable development goals. Our curriculum units covered biological, personal, social/cultural, and political/economic aspects of kūmara, kōwhai, and harakeke. These plants are significant in Aotearoa New Zealand history and culture. Hence, the project harnesses the values of place-based education in supporting students to develop a sense of "Who am I?" with respect to "Where am I?". The team collaboratively planned two 1-week teaching and learning sequences in each school. Based on the data, including records of planning meetings, teaching materials, lesson observations of each lesson, conversations with students and collection of artefacts, teachers' post-lesson reflections, and surveys, we constructed vignettes as snapshots of the teaching and learning sequences. These vignettes responded to the questions about how we addressed plant blindness and supported Years 5–9 students to envision science-related possible selves. In short, the team agrees that: (1) a focus on one single plant that is culturally relevant to students and Aotearoa could harness pedagogies that help students to see the significance of plants; (2) elements of the past, the present, and the future of the plants formed important contexts for learning; (3) teachers' funds of knowledge and their experiences/knowledge in informal contexts and previous careers could enrich their planning and teaching.

Introduction

There is a clear need for students to develop an understanding of science concepts and practices in ways that foster their sense of a “possible self” that encompasses being a citizen who makes active use of science, and, in some cases, someone who might become a scientist. Achieving these goals is known to be a challenge for teachers as they seek to enact place-based approaches to teaching and learning (Ministry of Education, n.d.). Over time, the number of families/multigenerational families working directly with the land and with plants has declined, meaning many children have fewer opportunities to develop a close relationship with the land and with plants. Indeed, data from the 2018 Census show that 80% of people under 15 years old reside in urban areas (Ministry for Primary Industries, n.d.), and this was the case for many/most of our student participants. In contributing to the growing interest in teaching about plants in outdoor spaces (as reflected in various recent features in *Education Gazette*[1]), our project’s combined focus on plants, place, and possible selves aimed to fill this gap as part of enriching students’ experiences of science through engagement with culturally significant and native plants in the schools and the local area.

As a team of two researchers and three teachers—one from a primary, one from an intermediate, and one from a high school—we designed place-based teaching sequences focused on plants that were culturally significant to Māori and prevalent locally. Through this approach we responded directly to *The Statement of National Education and Learning Priorities* (Ministry of Education, 2021) in contributing to “meaningfully incorporate te reo Māori and Tikanga Māori into the everyday life of the place of learning” (priority 5, Objective 3: Quality teaching and leadership) and “[design and deliver] education that responds to the needs of Māori learners/ākonga, and sustains their identities and cultures” (priority 2, Objective 1: Learners at the centre).

1 Harvesting the future of the primary sector, 2024
https://gazette.education.govt.nz/articles/harvesting-the-future-of-the-primary-sector/
Sowing the seeds of environmental success, 2024
https://gazette.education.govt.nz/articles/sowing-the-seeds-of-environmental-success/
A whole-school approach to wellbeing in Tāmaki Makaurau, 2023
https://gazette.education.govt.nz/articles/a-whole-school-approach-to-wellbeing-in-tamaki-makaurau/
A passion for environmental science nurtures young kaitiaki, 2022
https://gazette.education.govt.nz/articles/a-passion-for-environmental-science-nurtures-young-kaitiaki/

Why a focus on plants through place-based science education?

Compared with animals (e.g., native birds and dolphins in Aotearoa New Zealand), people pay less attention to plants (Balding & Williams, 2016). The diversity of plants and the vital role they play in the ecosystem and our survival tends to be overlooked. Plants in all their variety, complexity, and uses are often underrepresented in the curriculum: photosynthesis is taken as a biochemical process with a focus on the reactants and products, models of food chains/webs and the ecosystem might include several different types of animals, but plants are often portrayed as a single category. There is very little recognition of the diversity in plant life cycles; for example, kūmara propagate through their tubers in Aotearoa and harakeke leaves do not come from stems (Stagg & Dillon, 2023). The central roles plants play in providing habitat for many species, in helping to regulate Earth's climate, and as direct or indirect sources of food and medicine is not always explored. Researchers have found students' knowledge of plants is often limited; only 30% of the Year 9 New Zealand student participants in TIMSS 2019 were able to explain how an increase in gardens reduces the amount of carbon dioxide in the air (Cheng, 2023). This lack of awareness and appreciation of plants underpins the notion of "plant blindness", which may be characterised as failing to take notice and overlooking the importance of plants to our daily lives, having limited hands-on experience with growing, observing, and identifying plants, and being insensitive to the aesthetic and sensory qualities of plants (Wandersee & Schussler, 2001). More recently, there has been a move away from the implied deficit positioning of plant blindness to consider plant awareness (Parsley, 2020). Both concepts raise similar concerns that we need to attend to plants in our local environments.

One way to address the vital role that plants play is for students to learn about the importance of plants in their daily lives, and in their local cultures and history (Amprazis & Papadopoulou, 2020). The place-based study of plants can readily address these matters by including a focus on understanding cultural practices, traditions, and uses of plants in ways that involve members of the local community. At a more personal level, a place-based focus on plants can support the development of a "botanical sense of place" (Wandersee et al., 2006) by adding to the experiences and memories students have of plants and a place. The notion of a botanical sense of place opens the possibility of making connections with students' knowledge of and aesthetic, social, and cultural experiences with plants and place. It creates an opportunity to move beyond plant blindness to "love", as argued by McDonough et al. (2019); that is, to develop knowledge, relationships, and empathy (Chawla, 2020).

Within Aotearoa New Zealand, place-based education owes much to the work of Wally Penetito. Penetito (2008) proposes place-based education attends to identity (Who am I?) and location (Where am I?). He points out that, while place-based education is intended to address Indigenous aspirations, the objectives and strategies advocated benefit everybody and encompass environmental education as well as social-emotional learning and wellbeing. Place-based science education can support the development of student identity and student understanding of local history and foster a sense of belongingness to place; it can readily include aspects of culturally responsive education

(Semken & Freeman, 2008). What is "local" in place-based science education can range from the school grounds to a wider catchment and anywhere in Aotearoa that shapes our society. In our study, we were particularly interested in the school grounds and immediate environment as a frequently experienced and readily accessible place. Besides the aesthetic values, increasingly school grounds and gardens are being used to provide students with opportunities to experience nature (Stevenson et al., 2020), understand and experience biodiversity (Chawla, 2024), including our native flora (Simmonds & Green, 2023), and grow vegetables as part of health/nutrition education.

Within place-based education, the focus on understanding cultural practices and traditions means that past understandings and uses of plants are of as much interest as those in the present and possible future. Important in our context, this focus takes account of and values the funds of knowledge students and teachers (Cowie et al., 2023) bring to curriculum learning from their everyday lives and backgrounds. It also supports dialogue between "Western" science and Indigenous sciences (Aikenhead, 2006; Buxton, 2010; Herman et al., 2021). Within Aotearoa New Zealand, educators and scientists have used the metaphor of braiding to conceptualise how science knowledge and Mātauranga Māori might come together in productive dialogue (e.g., Macfarlane et al., 2015; see Wilkinson & Macfarlane's (2021) work on river ecology). In our place-based plant study we explored these possibilities through a focus on three plants of local social and cultural significance, as described in more detail in the next section. We anticipated that the braiding of science and Mātauranga Māori would create social norms and values that embraced and honoured Māori ways of knowing and enhance student engagement (Penetito, 2011).

Why a focus on science possible selves?

While the attention of international comparative studies such as The Trends in International Mathematics and Science Study (TIMSS) or Programme for International Student Assessment (PISA) tends to be directed towards measuring content knowledge, science practices, or epistemic knowledge and attitudes broadly (Mullis et al., 2021; OECD, 2019), there is a need to understand how students see themselves in relation to science (Bolstad & Hipkins, 2008; Penuel & Bell, 2011). How to foster student confidence, competence, and affiliation with science so that they see a place for science in their lives in the short and longer term resonates with Penetito's (2008) focus on "Who am I?" and his citation of Reedy who asserts "the problem is not how far we can refer back in our culture, but how far we can bring what we had before into the present and project it into the future" (Penetito, 2011, p.42). Contextualising the idea in mana ōrite mō te Mātauranga Māori imperative (Berryman et al., 2018), it is important students come to appreciate Mātauranga Māori as a knowledge system that explains natural phenomena not only in the past but also now and into the future.

The notion of "possible selves" offers a way to consider this. It refers to "individuals' ideas of what they might become and what they would like to become" (Markus & Nurius, 1986, p. 954). A substantial body of research has investigated science career-oriented possible selves (e.g., Buday et al., 2012; Fan et al., 2023; Wonch Hill et al., 2017). Less attention has been paid to how students envisage their possible selves in relation to the role science might play in their daily lives. This omission is significant given evidence students tend to disengage from school science from Years 7–10 even though their aspirations or engagement in science in daily and informal settings, while not high, do not demonstrate a decreasing trend (Martin et al., 2021). This project sought to harness and develop students' interest in science in their daily lives outside of school through teaching and learning units that supported them in envisioning a science-related possible self.

Research questions

1. What can place-based plant-focused science teaching and learning sequences look like?
2. In what ways do the teaching and learning sequences (kūmara, kōwhai, and harakeke as examples in this project) help develop students' botanical sense of place?
3. In what ways do the teaching and learning sequences inform student views and assist them to envision science-related possible selves?

Research design and approach to analysis

This project built on an established research partnership between Maurice Cheng and Bronwen Cowie (University of Waikato) and Chloe Stantiall (Silverdale Primary School), Nick Bryant (Ngā Puhi and Ngāti Whātua) who was at Hillcrest High School until August 2022 and then Matamata College for the TLRI in 2023, and Natalie Thompson (Berkley Middle School). The team came together as a group of teachers from the Hillcrest Kāhui Ako who shared a desire to enhance student interest and engagement in science, and an aim to incorporate Mātauranga Māori in science lessons.

We employed a collaborative research design (Penuel et al., 2020) whereby all participants are positioned as co-researchers and priority is given to making a conceptual and a practical contribution, to engage with community members, and to take account of context. It was as a team we decided to explore plant-focused, place-based science teaching sequences and the development of students' science possible selves. Kūmara, harakeke, and kōwhai were selected for student investigation because of their cultural significance and local prevalence—teachers and researchers could access internet resources, and they featured in the local environment (roadsides, school grounds, and, in the case of kūmara, Te Parapara at Hamilton Gardens). The three plants embodied important science/biology ideas and were a focus for current investigation by scientists, with these investigations often including Mātauranga Māori (e.g., Barber & Higham, 2021). Additionally, team members, their whānau, and their friends were involved in cultivating and/or making use of these plants (e.g., the use of harakeke for weaving and growing kūmara).

1. Data on teaching and learning sequences

We held a project team meeting before the first teaching and learning sequence and two meetings before the second sequence where we focused on: (i) developing our understanding of local plants and their cultural relevance; (ii) developing and sharing ideas for lesson sequences; (iii) reflection on and analysis of lesson sequences; and (iv) co-designing assessments. Meetings were audio recorded and any materials produced were photographed/collected digitally. Besides planning meetings, the team also met twice to discuss observations of students' engagement, science learning, and developing a botanical sense of place and relationships with science. Both Bronwen and Maurice participated in classroom observation for all the lesson sequences. Field notes and audio records of the classes were taken; slides, displays, board work, displayed materials, and student work were photographed as appropriate. Data gathered were synthesised as classroom vignettes, through which we report and discuss how the teaching and learning sequences answer the research questions.

2. Data on student learning and development

Besides classroom observation and student artefacts (e.g., their writing and drawings in the form of postcards, poems, and infographics) we co-designed and conducted short surveys to examine the following:

(A) *Students' interest in, valuing of, and connections with plants*. The survey "Plant and I" is made of three 5-point Likert-scale items: (1) I see myself related to plants; (2) Plants are important to me; and (3) I want to know more about plants. Students were also invited to draw or write to discuss their choice from one of the faces: 🙁😕😐🙂😊. Their responses would reflect a degree of students' plant awareness/ blindness.

(B) *Science-related possible selves*. The survey "Thinking about myself now and my future" includes 13 items, of which there were six pairs of items inviting students to reflect on their present and future orientation about science (e.g., "Science is important to me" and "Science will be important to be"), and an item on their career choice (i.e., "I would like a job that involves using science"). Students were given the four options of "strongly disagree" (coded as 1 in data analysis), "disagree" (as 2), "agree" (as 3), and "strongly agree" (as 4) along with emoji faces.

It would have been ideal to conduct each survey before and after each teaching and learning sequence, but this would mean students would complete a total of eight surveys. After balancing factors such as value to students in doing the surveys and the nature of the study, we collected the following data. For "Plant and I", we collected the data from Silverdale before teaching sequence 1 (Harakeke) and after teaching sequence 2 (kōwhai), we collected data from Berkley at the end of the second sequence, and from Matamata before and after the second sequence. For "Thinking about myself now and my future", we collected the data from Silverdale and Berkley after each teaching sequence, and from Matamata before and after each of the sequences. In Matamata, as per the school timetable and curricular structure, the teaching sequences involved two different groups of students. Compared with the students of Silverdale and Berkley whose learning experiences about plants spanned nearly a year, each group of students in Matamata only had one week of learning experiences.

Key findings

This section addresses the project research questions using vignettes of learning and teaching. Although different vignettes are presented under different research questions, they can all be read as relating to all the research questions. For example, a vignette that illustrates future-focused research on a plant (RQ1) also illustrates how students might be supported to envision their science-related possible selves (RQ3). Such linkages are made in our discussion.

1. What can place-based plant-focused science teaching and learning sequences look like?

Given the pressures on schools, we agreed as a team that teaching sequences for our project would be completed within one week and focus on one plant (Table 1). The richness of what teachers and students achieved in this time illustrates the value of a short, intense, and in-depth focus; it illustrates the breadth of learning that weaving together science, Mātauranga Māori, and students' funds of knowledge can achieve through an expansive focus on one plant.

TABLE 1. Summary of focus plants and timing of the teaching and learning sequences

Chloe (Years 5 and 6)	(1) Harakeke—first week of Term 2 (end of April) (2) Kōwhai—first week of Term 4 (early October)
Natalie (Years 7 and 8)	(1) Kūmara—middle of Term 2 (end of May) (2) Kūmara—last week of Term 3 (middle September)
Nick (Year 9)	Students take different modules throughout the year, meaning two different Year 9 classes participated in the project, one in Term 2 (middle May) and the other in Term 4 (middle October). Both classes focused on kūmara.

(Note: The kōwhai unit was timed to coincide with flowering; Natalie's second unit was at the time for planting kūmara.)

Linking the past, present, and future: Kūmara as a focal plant

Each of the teachers, in different ways, included: (i) information about the past cultivation, significance, and uses of their chosen plant; (ii) direct experience with the plant and/or some of its aspects; and (iii) consideration of current research about the plant. This breadth of focus allowed us to include Mātauranga Māori, and our own and students' funds of knowledge in the curriculum/lesson sequences in meaningful ways. The teaching of kūmara illustrates these aspects.

Natalie anchored her teaching sequence on the scarcity of kūmara due to a recent cyclone (Gabrielle); Nick focused on kūmara as a key source of carbohydrates for Māori in the absence of native plants rich in carbohydrates when they arrived in Aotearoa New Zealand. Natalie and Nick were each able to recount stories of their own and their whānau's gardening, storing, and eating kūmara as contributions to the curriculum.

Both Natalie and Nick used the *Connected 2020* story *Whakaotirangi and her Kete of Kūmara* (Gordon-Burns, 2020) with their classes. This story outlines how Whakaotirangi (a female leader from Tainui) had brought kūmara and other plants to Aotearoa and describes the techniques she used to plant, grow, and store kūmara. Her actions meant Tainui could settle in one place. Both teachers also set up kūmara in shallow water to sprout shoots (tipu) (Figure 1 and Figure 2) that students would plant at a later date—Natalie with the same class the second time she focused on kūmara (Figure 3) and Nick with his second class.

FIGURE 1. Natalie's first kūmara unit (in May)

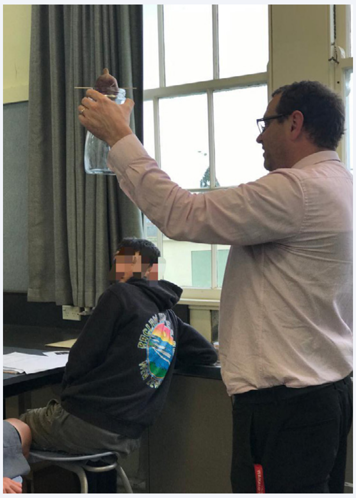


FIGURE 2. Nick's first kūmara unit (in May)

FIGURE 3. Kūmara tipu ready for planting (in September, Natalie's second unit)

For Natalie, the planting of tipu enacted her future focus—her class knew the kūmara were being grown for the school celebration hangi for Matariki. For Nick, the future focus came through his sharing of news reports about current scientific investigations to identify varieties of kūmara that can resist higher temperatures amid climate change (Evans, 2020). The following vignettes present snapshots of the teaching by Natalie and Nick that focused on growing of kūmara at a place familiar to students and at the place linked with Nick's whakapapa respectively.

Vignette 1: Planting of kūmara (Natalie—2nd sequence)

A main goal of Natalie's teaching sequence was for the students to grow kūmara for use in a hangi for Matariki 2024. To prepare for the planting, the class had to make several decisions including, "How much do we plant?" and "Where exactly to plant kūmara?" (details on soil testing and observation are in Vignette 7, p. 18). The "where" question was not only a scientific one; the class also initiated the idea of making the seedlings safe by putting up a sign asking people: "Do not pull the plants."

By September, the kūmara the students had set aside in May (Figure 1) had developed roots and sprouted tipu (Figure 3) and, according to Māori wisdom, the blossoming of kōwhai meant that it was time to plant kūmara. The class researched how exactly to plant kūmara, then, with knowledge about building mounds, they did the actual planting. In small groups both boys and girls took care to ensure the mounds were sturdy and the tipu roots were in a J and facing east, as learnt through Mātauranga Māori (Figure 4).

FIGURE 4. Students planting kūmara)

In this activity, Natalie's students learning to grow kūmara was important not only for their own learning but also contributed to their community through the Tikanga of learning that is an important value for Māori (Mead, 2016). The growing of kūmara in their school grounds came with the possibility of creating new memories for students about their school, a point we discuss in the next section (RQ2) as the development of a botanical sense of place as a strategy to tackle plant blindness.

Vignette 2: Impact of climate change on the agriculture of kūmara (Nick—1st sequence)

On the third day of the teaching sequence about kūmara, Nick started the session by writing jumbled letters on the whiteboard “r k ū a a m”, “i e c t m l a”, and “r o h t y e b a d a r c”. Students were quick to identify “kūmara”, “climate”, and “carbohydrate” from these letters. Then he shared: “I’m from Kaipara, my whakapapa goes back to Kaipara. I grew up in a tiny place called Titoki.” His whānau living there still grow kūmara. He continued: “I’m linked to Kaipara the capital of kūmara of New Zealand. Ruawai is where most of the kūmara that you eat in New Zealand comes from.” Next, Nick played a video from Kaipara Kūmara about the process of growing and harvesting kūmara. Watching the video a student asked: “What is growing kūmara got to do with science?” Nick responded saying this was a good question and invited students to keep reflecting on this as they watched the video. At the end of the video, Nick explained:

> Science comes into everything. Science definitely comes into food production. Science covers things like financial sustainability. But science comes into how we make sure that we can eat and feed each other. Science comes into testing what works and what doesn’t work. And all of that is part of the kūmara process.

Nick shared with the class the soaring price of kūmara and the floods in the north were related to climate change. He remarked: “Most New Zealand kūmara doesn’t deal with changes in temperature very well, and we know that climate change will change our temperatures. And that’s going to be a challenge for us.” With this background, he shared a news article about research on identifying heat-tolerant kūmara.

Nick’s teaching traced his whakapapa and his whānau as much as projecting into the future. Nick’s students appeared very engaged as he shared his whakapapa and how his whānau are involved in growing kūmara. This sharing was important to him building a more personal relationship with students, if not potentially providing a role model for his students who were growing up in a rural area and with whānau growing kūmara/gardening. Also, as reflected in the classroom exchange, a student was motivated to consider and ask the relationship between planting kūmara (of large and small scale) and science. Nick’s responses pointed to idea that “science comes into everything”, which we consider helped students to see science not only as a career but also as a part of their lives. The responses reflected the values of science possible selves in which students relate themselves to science in their daily lives (see Vignette 8 from Nick: “Who is a scientist?” when we address RQ3).

2. In what ways do the teaching and learning sequences help develop students’ botanical sense of place?

If students are to develop a “botanical sense of place” (Wandersee et al., 2006), they first need to become aware of the plants in their place. However, countering plant blindness involves more than simply noticing plants. It involves coming to see significance and developing a knowledge of plants, and of having aesthetic/affective experiences with plants and plants-in-place. While direct contact with the plants is essential, we illustrate that student experiences with plants can be extended to learning some history or stories about the plants that are part of our collective memory of our place and culture. We exemplify this finding through a vignette of how Chloe brought wonder to her class through kōwhai seed hunting on the school grounds, and Nick sharing his personal links with kūmara and its history. The following vignette illustrates how students responded to Chloe's use of a seed hunt to alert students to the presence of kōwhai in their school environs.

Vignette 3: Kōwhai seed hunt through purposeful observation of the school grounds (Chloe—2nd sequence)

It was mid-September and the kōwhai trees outside the school gate had started to blossom. Inside the classroom, the line "Whakatō ngā kākano kōwhai/Planting kōwhai seeds" was on the whiteboard. Chloe shared with tamariki that they would be collecting and planting kōwhai seeds. She had prepared a printout on the steps for planting seeds and tamariki took turns reading the steps aloud. One tamariki asked how deep they would put the seeds, and another commented she had used sandpaper to rub the seeds before planting.

Chloe led the class to the kōwhai trees (Figure 5). Initially, the tamariki focused on the seed pods on the tree and on the ground, looking at the seeds in them. Then, some tamariki noticed a few bright yellow seeds on the ground. It was as if something magic happened and other students searched for and noticed seeds. They paid particular attention to the soil and lawn under and near the trees (Figure 6) and found more and more (Figure 7). Back in the classroom, Chloe asked tamariki to share their observations of the kōwhai seeds they had collected. Their responses showed that they had carefully observed the colour, size, and shape of the seeds and used their hands to feel the hardness and smoothness of the seeds thus portraying observation as a multisensory/multimodal process.

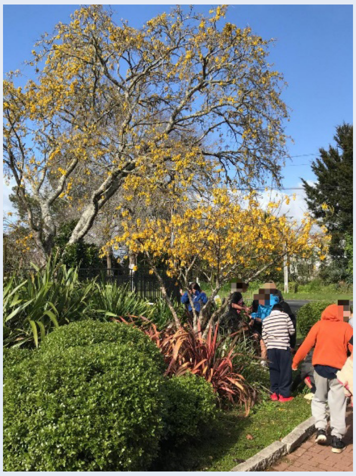


FIGURE 5. Collecting seeds under the tree

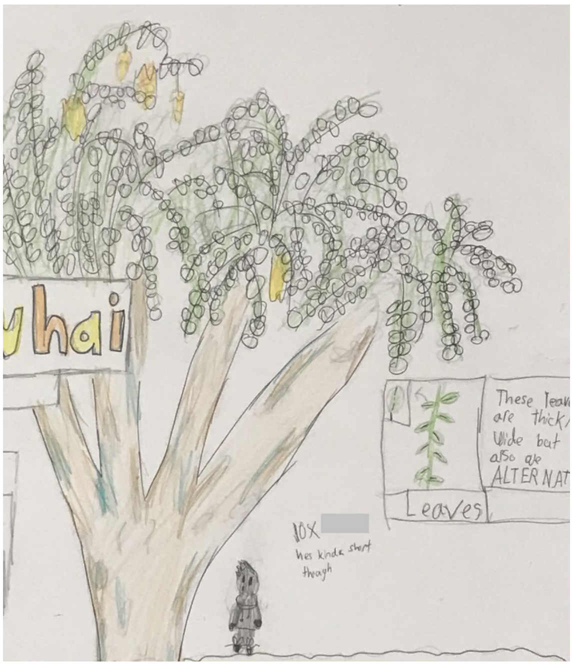
FIGURE 6. Collecting seeds near the tree

FIGURE 7. Once the tamariki found the first seed (the top circle), they noticed more!

The kōwhai seeds appeared to have been largely invisible to students until they went looking for them. When they began to do this, the seeds and the plants acted as a source of engagement, excitement, and learning. During the rest of the week, Chloe's students visited the kowhai trees in the grounds on several occasions to observe, collect, and take back to the classroom seeds, seed pods, flowers, and leaves. They observed and felt the bark and noted the form and height of the trees in situ. Towards to the end of the unit, the class went on a short bush walk near the campus and learnt how to contribute to i-naturalist when they observed kōwhai. These activities provided students with experience of the whole plant and its parts in situ and as specimens available for closer observation and analysis in the classroom. Chloe also used several internet-based resources—drawings, photographs, videos by gardeners and scientists—to introduce and illustrate ideas. At the end of the teaching and learning sequence, the students wrote poems about kōwhai. They also produced infographics to share what they had learnt with visitors to school.

Figure 8 shows a part of the infographic that Calvin (pseudonym) designed. He used his body to help viewers appreciate the height of a kōwhai tree in the school grounds. The work reflects his affective connections with the kōwhai on the school grounds and can be seen as both evidence of and contributing to his botanical sense of place.

FIGURE 8. A part of a Calvin's infographic that illustrates the kōwhai tree near the classroom. The annotation suggests viewers compare the height of the tree with the student's height. The side box includes information based on the student's close observation of kōwhai leaves. The tamariki name, after "10x", is greyed-out.

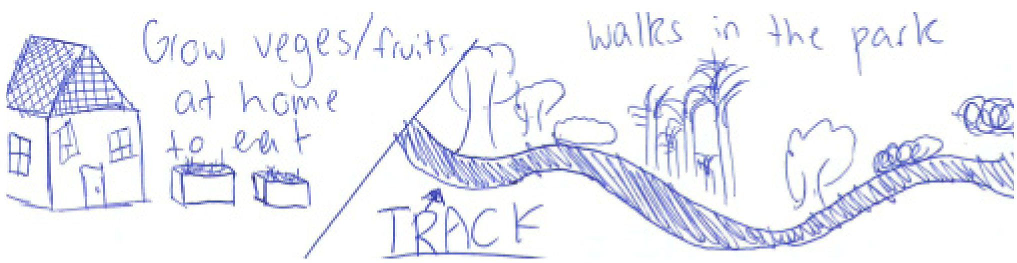


Immediately after the kōwhai teaching and learning sequence, the class average ratings on the survey prompts of "(1) I see myself related to plants", "(2) Plants are important to me", and "(3) I want to know more about plants" were 3.9, 3.6, and 3.8, respectively. Considering a 5-point scale with a mid-point of 3.0, the data suggest that students more related themselves to plants than not. More strikingly, in relation to a sense of place, in the item "After learning more about kōwhai, I feel the school grounds/playground/garden/campus has become more important to me", the average rating was 4 and all ratings were 3 or over. This suggests that studying kōwhai as a focal plant acted to connect tamariki with the school. About them noticing kōwhai, 17 of the 21 tamariki indicated "Yes, a little more" or "Yes, a lot more" in response to: "Do you feel that you see more kōwhai trees outside school after learning about kōwhai?" These results suggest that tamariki had taken a step towards plant awareness.

In Natalie's class, before students planted kūmara (Vignette 1), they made extensive observations (detailed in Vignette 7: Observing soil (Natalie—2nd sequence)) around the school in line with those made by Whakaotirangi. Their purpose was to determine the best place for planting. The process of exploring school grounds may help develop a sense of attachment to the place and the plant.

Students also rated the "Plant and I" survey items very positively after the second kūmara teaching and learning unit—with an average of 3.9, 4.7, and 3.7 on the items (1)–(3) respectively. While a few students referred to "oxygen" or "plants help us breathe" when they considered their relationship with plants, others contextualised their relationship with plants in terms of places close to them. For example, one student wrote: "I see plants are important to me because I love bush walks and they help people love." Another drew the following annotated diagram (Figure 9).

FIGURE 9. An example of a student's writing/drawing that demonstrates the ways that plants are important to her



Nick adopted a different approach to cultivating students' botanical sense of place. He candidly shared with his Year 9 class how he came to know the history and origins of kūmara (Vignette 4).

Vignette 4: Sharing a personal learning experience—whakapapa of kūmara (Nick—1st sequence)

Kūmara is a culturally significant plant in Aotearoa; however, it is not a native plant. Nick shared with the class that he came to know this during his visit to his sister in Guatemala, when he noticed a tuber that looked like kūmara was called "camote". From there, he began to search the origins of kūmara, and found they were from South America.

He shared with his students a map that showed how and when kūmara plants were brought to different parts of the world, and the variants in their name in different places. Students were amazed at Nick's learning and surprised to find that kūmara was not a native plant but had been brought to Polynesia around 1100 CE. They were also interested to see the variants of the names attached to the plant (e.g., uala, cumar, and cumal).

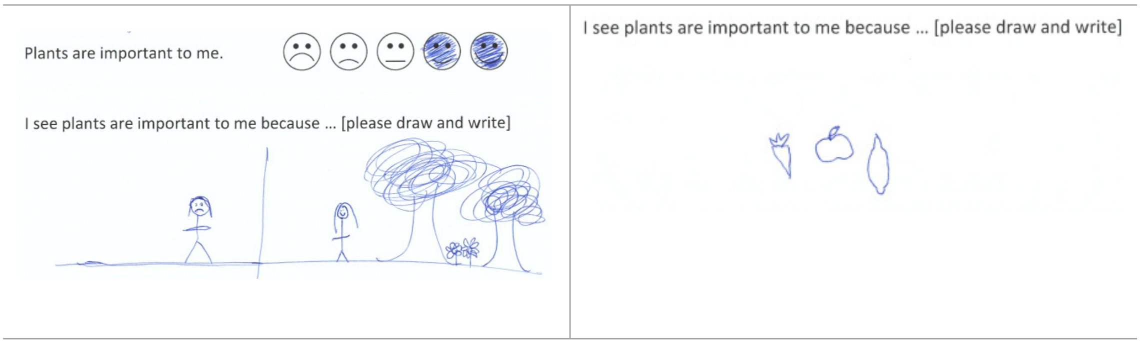
Compared with Natalie and Chloe's classes in which the focal plant was in the school grounds, Nick brought a historical global perspective to kūmara (its origin biologically), which students likely viewed as local, and Mātauranga Māori associated with it. His approach supported students to reflect upon and expand their knowledge of kūmara as an important plant in Aotearoa, which Wandersee et al. (2006) regard as a part of the botanical sense of place.

Vignette 5: Significance of kūmara in Aotearoa history (Nick—2nd sequence)

Nick taught food components (protein, carbohydrate, lipid, etc.) as part of his teaching about kūmara. After having students examine the food labels of various food products from supermarkets (e.g., cooking oil, brown sugar, muesli bars, canned beans, and bread) he invited students to report what they noticed about the major food components of these products. Then, he focused on kūmara, highlighting that (1) carbohydrate is a major food component of kūmara, and (2) while Māori found there was a plentiful supply of protein/meat in Aotearoa, carbohydrate sources were scarce except for kūmara, meaning its successful cultivation was critical (see the story of Whakaotirangi). There was discussion about whether kūmara leaves could be used as a vegetable. Nick told his students that kūmara leaves are regarded as tapu. A student quickly pointed out that harvesting the leaves would limit the growth of kūmara, and there were many other sources of leafy vegetables.

After the week of learning, Nick's students' rating of the item "Plants are important to me" had an average of 3.6. Also, five of the 19 students mentioned food or eating, which contrasted with the class's earlier writing when they mainly referred to plants producing air/oxygen and making them breathe. Figure 10 shows Toni's (pseudonym) drawings before and after the week in relation to the item of why plants are important to them. While the first drawing seems to suggest plants/trees make her happy (see the smiling face), the second drawing explicitly refers to fruit/vegetables.

FIGURE 10. Toni's drawings of the way that plants are important



In short, all three classes demonstrated in various ways that the teaching sequence had contributed to cultivating a botanical sense of place among students, from the most local (e.g., intensive study of kōwhai and the planting of kūmara in school grounds) to the global (e.g., the journey of kūmara). In all cases, students demonstrated emotional/affective responses to the plants at places familiar to them (e.g., as Chloe's students "discovered" kōwhai seeds on the ground, and Natalie's students checked out where to plant kūmara), and how kūmara came to Aotearoa New Zealand and how kūmara are grown and harvested in a large scale (in Nick's classes). In these classes, the teachers drew on their own funds of knowledge and other informal knowledges to enhance the relevance of the different focal plants with students. This was important in supporting students to envision their science-related possible selves, which we discuss in the next section.

3. In what ways do the teaching and learning sequences inform student views and assist them to envision science-related possible selves?

Our focus on science-related possible selves recognises that students need to develop the disposition to think with and take actions informed by science at this time when "fake news" and pseudo-science abound (Osborne & Pimentel, 2023). This is the case irrespective of whether they intend to be or become scientists. Using their focal plants, all three teachers made explicit links between the practices their students were engaging in and what scientists might do. They each emphasised curious and purposeful observation as an important skill scientists use to develop understanding and explanations (Eberbach & Crowley, 2009). Chloe and Natalie also supported their students to draw on Tikanga and Mātauranga Māori to inform their observations as they harvested harakeke and planted kūmara respectively. Nick challenged students in thinking who could be "scientists"/"practising science" in contexts such as growing kūmara now (in horticulture and agriculture) and in the future (in researching climate-change-resilient varieties of kūmara for agriculture).

Scientific observations around us (school grounds)

The following vignette demonstrates a way that students practised purposeful and knowledge-based observation and action supported by Mātauranga Māori when harvesting harakeke for weaving.

Vignette 6: Harvesting harakeke/Making sense of harakeke leaves (Chloe—1st sequence)

Chloe shared with the tamariki that they were going to harvest some leaves from the harakeke outside the school gate to use for weaving. Before they went to do this the class read and discussed the Tikanga of harvesting harakeke. The text outlined Māori have names for specific leaves: rito (child) for the central young leaf/s; awhi rito (parents) for the leaves each side of the rito; and tūpuna (ancestors) for the leaves outside the awhi rito. The type of leaves is more easily discernible when we observe near the base of the plant. Guided by Tikanga Māori, only tūpuna are harvestable, with awhi rito protecting the growing rito. The text also included that harakeke should not be cut on a rainy day and how the cut needed to be with an angle downward and away from the rito.

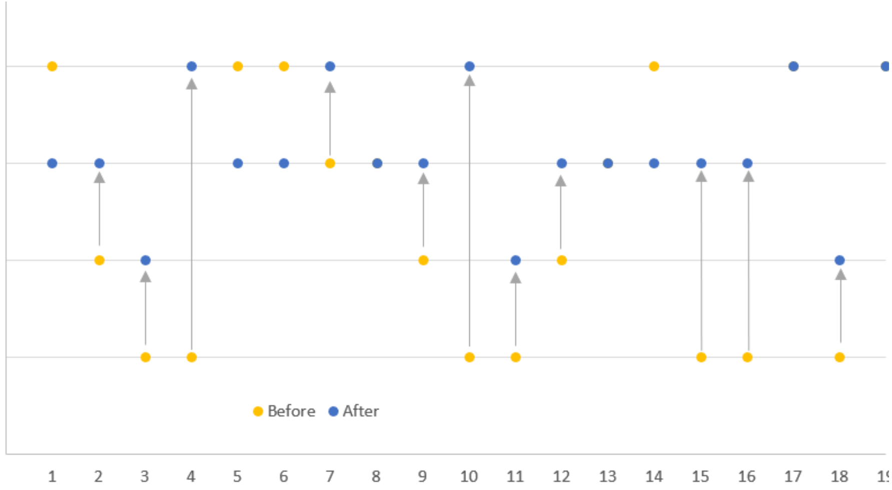
Chloe explained that, like scientists, tamariki would have to observe carefully to identify and differentiate tūpuna from rito and awhi rito when they harvest leaves for their use—observation as part of scientific practice was key theme of the unit. The class said a karakia then looked carefully to identify tūpuna. One tamariki said she had learnt from her whānau that the leaves bending outward were tūpuna. Her classmates wondered about this, and they traced an outward-bending leaf down to its base and confirmed that the leaf was a tūpuna.

Back in the classroom, Chloe highlighted the significance of observation in science and reiterated to tamariki they were practising what scientists would do. Her remarks that "You are all scientists" reinforced the idea that science was for them and that science ideas are practised in daily activities.

In this vignette, Tikanga and observational practice served the purpose of respectful and sustainable harvesting of harakeke. When the observation and harvesting were guided by Mātauranga Māori, one student was able to contribute to practice through her family's knowledge of how to identify tūpuna. Chloe built on the ideas the tamariki experienced in harvesting harakeke leaves in Term 3 when they collected kōwhai seeds. In both sequences, Chloe took the advantage of the plants being in the school grounds to ensure the class had ample time and opportunities to interact very closely with the plants. This supported students to gain a deeper understanding and develop stronger connections with both the plants and the place where they grew.

While it is not possible to make strong causative claims about student development of science possible selves, the "Thinking about myself now and my future" survey produced two notable results: (1) out of the 4-point scale, the class average of the *present selves* item "I like studying science" increased from 2.4 to 3.1 (standard deviation, sd: 0.7) before and after the kōwhai unit (in Term 4). Figure 11 shows the paired data of 19 students, of whom 11 reflected they like study science more. (2) The class average of the *future selves* "I would like a job that involves using science" increased from 2.1 to 2.8 (sd: 1.0). We speculate that it may be due to the focus on integrating science with literacy (in writing poems), numeracy, and everyday and cultural knowledge (in creating the infographics) when students could see the relevance of science.

FIGURE 11. Student (from no.1–19) rating of "I like studying science". Eleven students rated more positively after the sequence (represented by the upward arrows).



Natalie also supported her students to practise observation as scientists would. She linked their observation of features of soils and places for growing kūmara with Whakaotirangi's actions to cultivate kūmara. Whakaotirangi used her five senses in making a series of observations and Natalie's students also did this with their observations complemented by the use of pH paper.

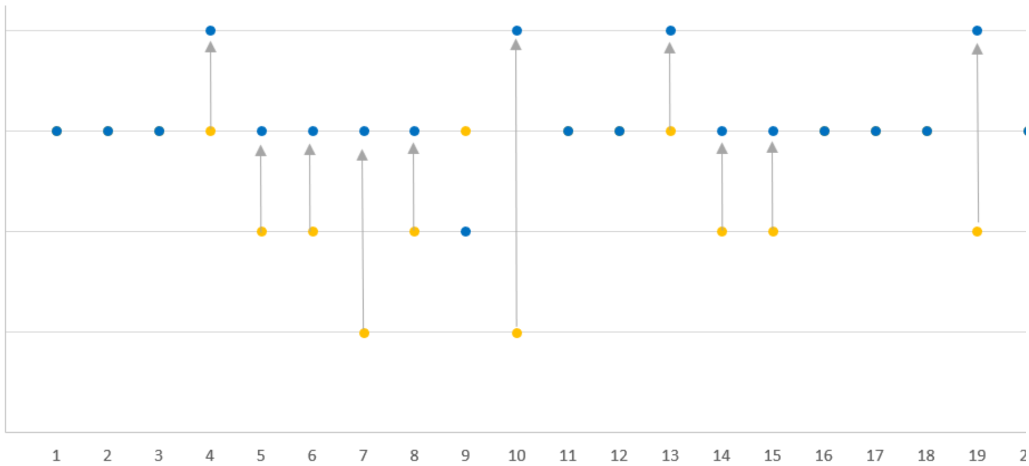
Vignette 7: Observing soil (Natalie—2nd sequence)

As they were reading the story of *Whakaotirangi and her Kete*, Natalie prompted her students to attend to the role of observation in Whakaotirangi's decisions about where and how to grow kūmara. Natalie highlighted that observations do not have to be conducted in a laboratory; Whakaotirangi's observations included reading the sky and weather (the macro-scale environment), and the look, texture, smell, and moisture of soil/earth (the micro-scale environment) and that this breadth of observations was what scientists would make. When Natalie asked for their thoughts, two-thirds of her students agreed Whakaotirangi had acted as a scientist would.

The next day, students worked to identify the best place on the school grounds to plant kūmara. They followed the path of the Whakaotirangi in observing the various aspects of soil at different places of the school, such as the side of the field and various gardening areas, and whether these places had plenty of sunshine. Knowing that kūmara grow best at pH 6–6.5, the students tested the pH of the soil with universal pH paper. As a part of the scientific observation practice, they recorded their data in a table on the spot. Their recording strategy allowed them to compare the data when they returned to the classroom. Back in the classroom when discussing their observations, a student added that she found some worms in the school garden pit, "so it's good soil".

In various occasions during her teaching, Natalie mentioned her own gardening experiences and past career as a chef as contributing to the wellbeing of her whānau. She also invited students to share their gardening experiences. These personal connections with science in daily life reinforced the idea that science is connected to daily life activities. We consider this emphasis would have contributed to the class rating of the *present selves* item "I like to use science in my daily life" increasing from 2.5 to 3.15 (sd: 0.5), with Figure 12 showing the paired data of 20 students, of whom 10 of them rated the item more positively after the second kūmara unit. The *future selves* increased from 2.75 to 3.3 (sd: 0.66) before and after the second kūmara sequence (with 11 students rated more positively).

FIGURE 12. Changes in students' rating of the item "I like to use science in my daily life" before and after the second kūmara sequence. Ten students rated more positively after the sequence (represented by the upward arrows).



Who is a scientist?

In our study, the notion of science-related possible selves was focused on supporting students to envision using science in their lives, thus moving beyond a narrow vision of being a scientist as a career. To help students envision science possible selves, Nick included information about the early cultivation of kūmara by Whakaotirangi alongside information about current research, as well as his mother being a scientist.

Vignette 8: Is Whakaotirangi a scientist? (Nick—1st and 2nd sequence)

The first time Nick taught the kūmara unit, he shared the article *Whakaotirangi and her Kete* with students and prompted them to focus on strategies that Whakaotirangi used to ensure a good kūmara harvest.

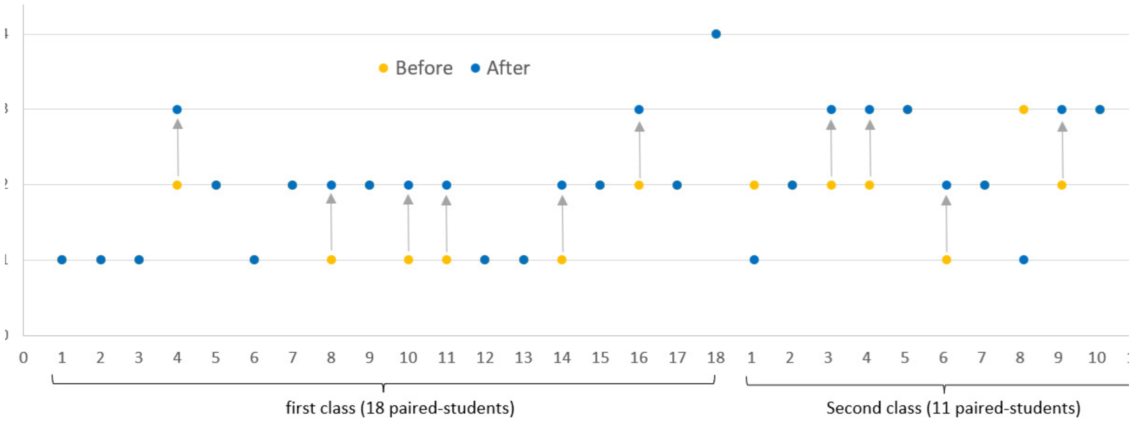
During the initial whole class discussion, many students did not view Whakaotirangi as a scientist. Nick introduced to the class that his mother, who knows a lot about growing kūmara and does grow plenty of kūmara in her garden, is a good scientist. He also showed students a photo of his sister sitting in a kitchen with a pair of cat earmuffs and asked if she was a scientist. The students doubted this but then were surprised when Nick shared that she was a conservation biologist doing research in Guatemala. Following on, he showed students a photo of Professor Nick Roskruge (Te Atiawa, Ngāti Tama) (but without his name, title, iwi, and what he does) and asked if the class thought he was a scientist. While students were wondering about this, he revealed that Professor Roskruge works on improving the quality of crops at Massey University. It was at this point students agreed that he was a scientist. The next day, Nick probed students' thinking through a simple survey about whether or not Whakaotirangi was a scientist and if what she did was scientific.

The second time Nick taught the unit, he devised a task sheet that prompted students to consider analytically which aspects of what Whakaotirangi did were scientific. Many students agreed she worked in a scientific way when she explored places for growing kūmara, the way she cultivated and stored kūmara.

The choice of scientists here was purposeful. It showed students real-life examples that science could be done by his mother when she grew kūmara at home as much as Professor Nick Roskruge researching kūmara. Scientists could be female (his mother and his sister) and male, irrespective of one's cultural background and how they look like (even with cat earmuffs!).

After one week of learning about kūmara, there is evidence that students moved to a more positive attitude towards science and saw themselves more related to science. In the first class (in May), out of the 18 students who completed both the pre- and post- of the survey "Thinking about myself now and my future" before and after the unit, seven students became more positive/less negative in the item "Science is important to me", with an increase from two to five students who "agreed" or "strongly agreed" with the statement. Also, six students became more positive/less negative about the future-self item "I would like to be interested in reading stories or news about science", with none of the students becoming more negative (Figure 13). Likewise, for this same item, among the 11 students who completed the pre- and post-survey in the second class (October), four students became more positive/less negative (Figure 13), and with an increase from three to five students who indicated "agreed" (as "3" in the y-axis). The results from these two classes point to the value of discussing media reports about the research on climate-change-resilient kūmara with students and the role of science in growing kūmara.

FIGURE 13. Changes in students' rating of the item "I would like to be interested in reading stories or news about science" before and after the kūmara unit. Six students from the first class became more positive/less negative; four students in the second class did (represented by the upward arrows).



The concept of science-related possible selves could be characterised by different ways that students associated themselves with science. Within the scope of the survey, there may be some associations between students' experiences and their responses to aspects of science-related possible selves. The use of media reports about kūmara in Nick's classes likely contributed to the increase in the number of students who expressed interest in reading more science news or stories.

Compared with existing approaches of enhancing students' engagement in science or supporting students to envision science-related possible selves (e.g., Godec et al., 2017), grounded in Aotearoa and plants significant to us, our teaching and learning sequences demonstrated the braiding of Mātauranga Māori and science. The focus on culturally and locally significant plants created classroom norms where both knowledges and values were honoured and interwoven together to support students to see themselves related to science. There is evidence suggesting that teachers' planning, resources they used, and their own background and interests made an impact on specific science-related possible selves to their students.

Implications

Based on our experience in planning, teaching, and reflecting on student learning and engagement place-based plant-focus units, we offer the following implications for teachers and curriculum leaders in Aotearoa and beyond.

1. Teachers' family/cultural background and informal knowledge are important resources for helping students to envision science-related possibilities

The notion of learning ecologies highlights that people learn in a variety of contexts and connections, which include friends in other professions, ex-colleagues, community groups (e.g., language classes), leisure/sport/home activities, whānau, the natural environment, published resources (e.g., magazines, books, social media), and so on (Cowie et al., 2023). Teachers planned and enacted the teaching sequences drawing on various contexts/connections within their personal learning ecologies. Nick shared his family background and connections (e.g., his sister being a scientist working in Guatemala, his mother and whānau being keen gardeners and kūmara growers); Chloe made use of her knowledge of te reo, gained through evening classes, to support student learning of te reo and about Tikanga; Natalie drew on her interest and knowledge from gardening when planning for her students to learn about growing kūmara. Teachers using themselves and their funds of knowledge (Moll et al., 1992) to enhance and contextualise ideas helped students see how various aspects of their daily lives could be related to science. It seemed to support students to contribute their funds of knowledge and to envision science-related possible selves that go beyond the career-oriented scope, such as Nick's questions about "Who is a scientist?", Chloe's students' contributions about how to plant kōwhai seeds and identify tūpuna leaves of harakeke, and Natalie's students' sharing about their gardening at home. Therefore, we suggest teachers deliberately draw on the resources within their learning ecologies for curriculum planning and teaching to enhance students' awareness of how various contexts/connections in their lives are science related.

2. Make active use of the school grounds, immediate local environment, and Aotearoa New Zealand bicultural context in teaching science

Our study explored a place-based approach to challenging plant blindness, meaning it was logical to look to the school grounds and surrounding environment when selecting a plant. We were all surprised and delighted with students' responses to locating and investigating a plant within the school grounds, a plant which, to that point might have been invisible and of no interest to them. The teaching units had a combination of interrelated elements that supported the linking of the past, present, and future of plants:

(i) a focused and in-depth study of a single plant; (ii) valuing Mātauranga Māori and science; and (iii) a focus on timeliness of teaching specific plants to harness students' interest/attention.

(i) In our study, students spent a week studying a single plant—harakeke, kōwhai, and kūmara. Teachers selected these plants on the basis that students could reasonably be expected to be familiar with them, they were growing in the school grounds, and they were of significance to (local) Māori. This, and the teachers' deliberate focus on the past, present, and future of their focal plant, allowed teachers to introduce, braid together, and practise te reo, Tikanga, and Mātauranga Māori related to the focal plant and science. A single plant, when ideas and practices from its past, present, and future are included, can provide engaging and exciting learning experiences that address plant blindness and develop a sense of place among students when students have easy and regular access to the plant.

(ii) Teachers maintained a clear focus on Mātauranga Māori. Teachers crafted and wove together activities that meant cultural knowledge was respectfully introduced and played an active role in student learning about the focal plants and what it might mean to be a scientist/work in a scientific way. This was the case when Chloe's students practised observation and harvesting of harakeke, when Natalie's students identified the best place for planting kūmara guided by Whakaotirangi's care in observing the environment, and when Nick drew his classes' attention to the links between Māori cultural and commercial practices for growing kūmara nowadays. These teaching episodes demonstrated the contribution of Mātauranga Māori and Tikanga (e.g., when harvesting harakeke), tapu (e.g., not harvesting/consuming kūmara leaves), values of manaakitanga (e.g., planting for the kūmara for next year's students, and making infographics to inform school visitors of kōwhai) were also present. These enriched students' botanical sense of place and science-related possible selves.

(iii) Timing emerged as a factor to consider when developing a teaching sequence to address plant blindness. In our study, lessons were timed to take advantage of something distinctive about the plant and of opportunities for action. Chloe's class studied kōwhai when the trees were in flower (early October); kūmara was a focus at times when tipu could be sprouted and planting was appropriate, with students started to grow kūmara in May before the planting in October. This acted to entice students' interest and sensitise their awareness of these plants.

Besides aligning the teaching time with the life cycle of specific plants, teachers also made use of the timeliness of relevant news. At the local scale, teachers drew students' attention to the immediate aftermath of cyclone Gabrielle and the soaring price of kūmara. At the global level, Nick referred to the latest scientific research about identifying varieties of kūmara as a response to climate change and extreme weather. These considerations motivated students and supported them to see the relevance of science to their daily lives and society as a step towards developing students' science-related possible selves.

3. Consider a wider scope of science and scientists for science-related possible selves

The notion of possible selves invites people to consider who they might and might not want to be and become. We pursued a dual agenda in this regard: that students would become (i) people who were aware of plants and their pivotal roles our lives and (ii) people who appreciated the role and value of science and Mātauranga Māori in their everyday lives, and in some instances wanted to pursue science/science-related careers. As noted earlier, teachers sharing their funds of knowledge can provide insight into and examples of these possibilities. Stories about "scientists" such as that about Whakaotirangi also provide information students can use to envision possible futures. Chloe (as in Cheng et al., 2023), Natalie, and Nick each used *Whakaotirangi and her Kete* to introduce Mātauranga Māori to their students while expanding students' scope of what counts as science and who could engage in scientific activities/practice. Besides the temporal past–present–future focus, the story is linked with Tainui of Waikato where this project is grounded. With Natalie's background as chef/gardener and reading of news (climate change/relevance for future), Nick, his whānau and research regarding heat-resistant varieties of kūmara (relevance for future), Chloe's passion in te reo, use of citizen science in i-naturalist, and creating infographics (as scientific communication) for visitors, they amplify the relevance of science to students and could facilitate envisioning their possibilities about the roles of science in their daily lives and possibly in their future careers.

In summary, we suggest that, to support students to envision science-related possible selves, teachers do not necessarily have to look far afield but rather to consider (i) drawing on resources from their learning ecologies, (ii) anchoring units on plants in school grounds and local environment, (iii) identifying people in the past and currently who have shaped/are shaping our understanding and place, and (iv) creating opportunities for students to contribute into the future.

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Chloe Stantiall is a Year 5-6 teacher at Silverdale Normal School. In 2024 she received a study award to study te reo Māori at Waikato University. Her interests in the classroom include getting kids excited about speaking te reo Māori and teaching through an integrated, inquiry-based learning model.

Nick Bryant (Ngā Puhi, Ngāti Whātuā) was initially a Head of Science when he worked on this project. He moved to Matamata College as Deputy Principal in 2022 and still enjoys teaching Science. His interests include culturally responsive pedagogy and critical thought, focusing on mātauranga Māori.

Natalie Thompson is a classroom teacher and team leader at Berkley Normal Middle School in Hamilton. She is passionate about creating a learning environment where students are engaged in many learning opportunities whilst allowing students to flourish as individuals.

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