Empowering Environmental Guardians: Using Collaborative Systems Thinking to Solve Real-World Problems in a Year 10 Girls' Science Classroom

Alexandra van der Loos

Westlake Girls High School, Auckland, Aotearoa/New Zealand

Abstract

This action research study delves into the intersection of systems thinking, collaborative skills, and the empowerment of 14–15-year-old girls in a Year 10 Science classroom as *kaitiaki* (environmental guardians). The project aimed to enhance the confidence and collaborative capabilities of the girls through the implementation of systems thinking techniques within the context of an environmental awareness campaign centred around a local waterway, Wairau Creek. In teacher-selected teams of 4-6 students, the girls were granted autonomy in structuring their collaborative groups, with no predefined roles or instructions provided. Emphasising the interconnectedness of environmental systems, the curriculum guided students through the exploration of a nearby creek, conducting water health assessments and engaging with community experts to gain insights into the challenges facing the waterway. This study builds on existing literature regarding systems thinking, extending its application to address a notable gap – the impact on, and implications for, girls' collaborative skills. By allowing students the freedom to apply systems thinking as they deemed appropriate, this research uncovered how such an approach influences the development of teamwork, relationships, communication, and leadership skills among girls, with an aim to be shared with different departments across the school and to be easily implemented at any year level by educators across the globe.

Glossary

Collaboration: A process where individuals work together, combining their strengths, skills, and ideas to achieve a shared goal.

Community of Practice: Groups of people who share a common interest and regularly interact to learn from each other. Groups with similar goals come together to exchange knowledge, experiences, and insights. Members collaborate to solve problems, share best practices, and enhance their expertise in a particular field. This supportive community fosters a sense of belonging and helps members collectively grow and adapt to changes within their shared domain.

Empowerment: Successful empowerment of girls in this context entailed providing them with the knowledge, skills, resources, and support systems necessary to actively participate in addressing environmental issues.

Environmental guardians: Relates to the Māori idea of *kaitiakitanga* which means "environmental guardianship". This involves addressing real-world problems in the environment and establishing meaningful actions to protect and/or raise awareness of the local waterways, land areas and ecosystems as *taonga* (treasure).

Mātauranga Māori: The knowledge system of the Māori people, the indigenous population of Aotearoa/New Zealand. It covers various areas like language, arts, sciences, and cultural practices, all

rooted in their ancestors' wisdom and a holistic view of the world. This knowledge emphasises how everything is connected in nature and plays a crucial role in preserving Māori culture, identity, and sustainable use of resources in their communities.

Systems thinking: "An approach for examining and addressing complex behaviours and phenomena from a more holistic perspective" (Orgill et al., 2019). This involves examining an issue as a whole, alongside breaking it down into small parts (as per traditional reductionist teaching).

Empowering Environmental Guardians: Using Collaborative Systems Thinking to Solve Real-World Problems in a Year 10 Girls Science Classroom

Introduction

In the ever-evolving landscape of education, fostering global citizenship and environmental stewardship in our students is essential. As teachers, we are entrusted not only with imparting knowledge but also with instilling in our students the confidence and skills necessary to navigate and effect change in their communities. The overarching action research topic for the 2023-2024 IGSC action research cohort, "Engaging the power of many voices - Leveraging girls' collaborative spirit toward courageous and joyful learning," served as a beacon, illuminating the need for a pedagogical shift that embraces inclusivity, collaboration, and student agency. Inspired by this call to action, I embarked on a journey of reflection, re-evaluation, and innovation within my Science classroom. Central to this project was a profound consideration of how to support girls to amplify their voices, empowering them to become agents of change in the realm of environmental conservation. My research is closely aligned to the strategic priorities of Westlake Girls High School, which aims to develop and equip *mana wāhine* (empowered young women) for global success by knowing our *ākonga* (students), inspiring growth, enhancing *hauora* (wellbeing) and incorporating local curriculum design in our pedagogy (Stanley & Westlake Girls High School, 2023).

Reflecting on my practice, it became evident that traditional teaching approaches often inadvertently stifle the voices of students, particularly girls, relegating them to passive recipients of information rather than active participants in shaping their learning experiences. Moreover, the imperative to cultivate a sense of environmental responsibility among our youth demanded a pedagogical approach that transcended disciplinary boundaries and embraced the holistic principles of systems thinking.

Driven by these reflections, I designed a curriculum based on my research question: How does using a systems thinking approach empower Year 10 girls in the Science classroom as collaborative environmental guardians? I created opportunities for hands-on scientific inquiry, where students not only gained an understanding of the ecological intricacies of a local waterway, Wairau Creek, but also delved into its historical significance and broader socio-environmental context. Crucially, this journey of discovery was enriched by collaborative engagements with local community experts, including municipal authorities and volunteer organisations, fostering a sense of shared ownership and collective responsibility.

Employing Mertler's (2020) action research process for this project allowed me to test this theory of pedagogical shift in my own classroom and back it up with current research and educational theories. It also provided the opportunity for me to help connect educational theory with real-world teaching practice and share my conclusions with my community and colleagues. By sharing these insights, it is my hope to inspire fellow educators to embark on similar quests, harnessing the power of education to nurture a generation of global citizens committed to *kaitiakitanga*.

Literature Review

In the classroom, systems thinking involves encouraging students to collaboratively explore complex subject matter as a whole, but with emphasis on the relationships between the components of a system, alongside traditional reductionist pedagogy in which concepts are taught by breaking them down into smaller parts. As there are "strong parallels between indigenous knowledge systems and complex systems thinking" (Hipkins, 2021, p. 93), my research aimed to explore how encouraging girls to use collaborative systems thinking approaches in their classroom community of practice could empower them to become *kaitiaki* of a waterway in their local community.

Orgill et al. (2019) state, "systems thinking approaches will be particularly important for educating future global citizens because … many of the challenges facing mankind now, like sustainability, are global and holistic" (p. 2721). These approaches have been applied to many fields, including healthcare, engineering, and commerce; however systems thinking is particularly meaningful when applied to science education, as it provides a framework that "connects chemical principles and concepts to familiar observations and experiences from students' daily lives" (Orgill et al., 2019, p. 2723). Hipkins (2021) proposes several teaching strategies that facilitate complex systems thinking in students, such as *visual models* (concept mapping, diagrams), *metacognitive conversations* (debates, learning-thinking-doing) and *harnessing interaction* (whole class discussions, group projects) (pp. 49-55). These collaborative and metacognitive teaching strategies support students to not only learn about complex systems, but also to develop the relevant thinking dispositions and habits to become complex systems *thinkers.*

There are a number of practices that foster a collaborative learning environment in the classroom that put relationships and connections at the forefront of the learning process, such as cooperative learning and communities of practice. Gillies (2020) describes cooperative learning as "students working together in small groups to accomplish shared goals" (para.1). Furthermore, Gillies notes that the success of cooperative learning is underpinned by five key elements: positive interdependence, individual accountability, promotive interaction, interpersonal skills, and group processing. These elements support students in understanding that their primary responsibilities are to provide one another with support, hold each other accountable and ensure learning is achieved by all members of the group.

Transforming small-group agendas into overall and common community strategies is discussed by Kapucu (2012) as part of the process of developing classrooms as communities of practice.

Participants are provided with the added value of an environment that "combines knowledge and practice and the opportunity to learn through relationships with their peers and practitioners in the community" (Kapucu, p. 585). When collaborative learning is understood as active participation in learning, rather than passive absorption of information, students working in a co-operative learning setting (small-group) can produce different actions that work towards a common goal in their community of practice (whole class) as part of a system of change.

While there is a great deal of research on the benefits of cooperative learning in the primary and secondary school setting, there is a gap in the literature regarding the development of classrooms as communities of practice in contexts below the tertiary level. Kapucu's (2012) research takes place in the tertiary setting; however, the overall essence of the findings can be applied to classrooms at primary and secondary levels.

Both collaborative learning and systems thinking are fundamental to the development of the "science identity". Research conducted by Brien (2017) found that girls have more difficulty than boys developing their identity, and therefore their interest, in science and scientific career pathways. Brien states further that by engaging in shared practice, girls can "develop identities as the kind of people who are knowledgeable about and involved in this particular practice" (p. 14). Science identities are formed when a student is recognised as the kind of person who engages in scientific work and understands the world in a scientific way. Collaborative systems thinking has the benefit of increasing the scope of scientific actions, facilitating the interactions between students and members of their community, and bolstering their understanding of the underlying scientific concepts involved. Trott and Weinberg's (2020) findings propose that the connection between collaborative systems thinking and science identity is enhanced when "opportunities for action" (p. 4) are introduced within and beyond the classroom. They add:

> Students need opportunities to see how the science they learn matters to their lives, to spread their knowledge across their networks of families and friends, and to transform the world around them as they engage collaboratively to translate their knowledge into action. (p. 3)

Both Brien (2017) and Trott & Weinberg (2020) agree that environmental science is an ideal context in which to introduce opportunities for action as it emphasises the real-world significance of science.

Local, real-world contexts are particularly highlighted alongside global contexts by Orgill et al. (2019) when discussing the importance of systems thinking as a lens through which students can view the "implications of their own decisions and actions on various political, social, economic and environmental systems" (p. 2726). Hipkins (2021) adds to this in a discussion of the tendencies of humans to "treasure the ecology of wild and remote places, while ignoring environmental degradation much closer to home" (p. 95). This attitude contributes to the dilemma students face while becoming systems thinkers in that they often position themselves on the outside of the system looking in.

Mātauranga Māori, the indigenous knowledge system of Aotearoa/New Zealand, provides a bridge between "acting local" and "thinking global," as it decentres the individual but still places great

meaning on their actions within the system by emphasising the relationships and connections they are impacting (Heke, 2018). The concept of *kaitiakitanga* as the driving motivation for students in their collaborative development of a wide-reaching, community-minded environmental action plan provides the opportunity to "explore two key questions: *Who am I?* (a question of identity); and *What is this place?* (a question of ecological consciousness)" (Hipkins, 2020, pp. 94-95). A survey conducted by Bolstad (2020) quotes one interviewee as stating that when considering environmental action "you draw from both Mātauranga and science: if we combine the science knowledge with kaitiakitanga practice, we can start adapting and mitigating" (p. 10).

With this combination of knowledge and practice in mind, I introduced collaborative systems thinking into a Year 10 Science class to "support students to perceive themselves as being *inside* complex systems, with an associated ethic of responsibility for our personal choices and actions" (Hipkins, 2021, p. 93). By contextualising their learning and fostering collaboration in order to work towards a shared goal of *kaitiakitanga*, I anticipated that girls would benefit from being "involved in a community (belonging) to engage in certain activities (doing), thus establishing their identities (becoming) to interpret the world around themselves (experience)" (Kapucu, 2012, p. 589).

Research Context

Westlake Girls High School is a large, multicultural school situated in Takapuna on Auckland's North Shore, New Zealand. The school has a roll of 2,322 girls (February, 2024) ranging from ages 12 – 18 years-old. Westlake Girls High School is a diverse community with a record of sustained levels of high achievement and a critical focus on student wellbeing.

My research project was undertaken with a class of thirty-one Year 10 girls towards the end of the school year, from September – November 2023. The school timetable afforded me seven one-hour lesson periods with this class per ten-day cycle. I made some allowances during this time for them to study for their end-of-year exams.

As participants, this Year 10 Science class was ideal, as the context suited the students' interests and I had already established my relationship with them throughout the academic year as their primary Science teacher. They consistently met expectations during the research period and were open to learning and applying new concepts to their studies.

To protect their privacy and ensure the necessary permissions were gained throughout the research period, I provided parents with an emailed summary of the project and explained the process of documenting their daughter's responses. Parents were made aware that students would not be disadvantaged by participating and that they had the ability to opt their daughter out of the programme if they wished. This email also explained that any data collected from their daughters would be treated confidentially and their published contributions would be anonymous.

The Action

This research project was centred around empowering girls as collaborative *kaitiaki* of a local waterway, Wairau Creek, through the facilitation of systems thinking in small focus groups, as well as

within a classroom community of practice setting. The students were tasked with producing an environmental action plan that focused on raising awareness of the issues Wairau Creek faces. In my role as facilitator, I pre-determined the groups, and the students were then given complete autonomy and fluidity when establishing their group dynamics and roles.

The programme began with direct instruction lessons on collaboration, communities of practice and systems thinking, to foster a common understanding of the key concepts and terms. We also looked into the history of the waterway and explored its significance to the Māori community as well as the native birds and aquatic life present in its ecosystem. These five one-hour lessons were structured around a brief introduction to the topic followed by whole-class discussions and brainstorming in their focus groups. The groups were provided with a booklet that included systems mind-mapping templates, glossaries, mātauranga Māori concepts, and focus questions for their planning and actioning phases. The students researched several of the United Nations Sustainable Development Goals (SDGs), such as "Clean Water and Sanitation" (Goal 6), "Climate Action" (Goal 13) and "Life Below Water" (Goal 14) to bring real-world significance and evidence to back up their plans (United Nations, 2023).

Three of the lessons involved speaking with, and listening to, community experts on Wairau Creek. Students were given the opportunity to meet with the leader of a local volunteer group, Pupuke Birdsong, and were also taken by representatives from the Wai Care programme through Auckland City Council to the creek itself to collect and test water samples, during which the students mind-mapped the systems involved in water health and how they interact (see Appendix A).

Following the initial period of instruction and exploration, the whole class chose a driving question as the domain of our community of practice through teacher-facilitated discussions. The consensus was that the students wanted to know how humans have impacted Wairau Creek over time and how they could raise awareness in the community. The students were then given time to prepare their action plans in their focus groups with the communal driving question at the forefront of their planning. Focus groups were encouraged to seek help from, and offer assistance to, other groups in the community of practice, and to make the most of their relationships with each other to create action plans that they felt were wide-reaching and effective.

The actioning phase culminated in the girls raising awareness in their community through a variety of different strategies, including fundraising for shade-providing trees, creating eye-catching posters to be displayed around the school and in nearby businesses, reaching out to a local reporter to have their project published in the community newspaper, and writing letters to our electorate's member of parliament to demand change in how the waterway is monitored and treated (see Appendix B).

Data Collection

During the seven weeks of fostering collaborative behaviours among Year 10 girls in my science classroom as they designed and implemented their environmental action plans, I employed polyangulation, with a key emphasis on qualitative data. While polyangulation entails the strategic

amalgamation of diverse qualitative and quantitative data collection techniques, my primary focus was on collecting the data of student voice. I achieved this by using a multi-pronged approach that incorporated an array of data collection methods, including semi-structured interviews, comprehensive surveys, reflection journals, videos, photographs (see Appendix C), field notes and classroom observations.

Each method contributed a unique vantage point on how the students' confidence in their ability to collaborate and raise awareness progressed. For instance, the interviews illuminated individual and group experiences and motivations pertinent to their collaborative efforts, while classroom observations provided a glimpse into the actual interactions and behavioural manifestations of these experiences.

I used a questionnaire during the period of research to document how the girls' confidence changed in several ways. I also distributed a Google Slides document with questions based on Gillies' (2020) five key elements of cooperative learning and the students submitted their reflections based on those questions each week. These question-based reflections provided my baseline data as well as the students' real-time cognition of their experiences collaborating with their groups.

At the end of the research period, I presented the students with an extended version of this questionnaire to gather their reflections on their experience as a whole. Two semi-structured interviews with two separate groups during their action planning phases were recorded and transcribed, while also ensuring there was room for clarification and follow-up questioning (Mertler, 2020). My questions focused on collaborative confidence, systems thinking, and how the girls felt they had developed as *kaitiaki* of their local environment.

Observations and field notes, organised into an adapted version of Mertler's (2020) Figure 5.1 (p. 244), documented the girls' collaborative journey, and were reinforced by video, photos, and voice notes. Polyangulation and qualitative data confirmed my research conclusions, offering a reliable lens to measure the growth of girls' confidence in their ability to collaborate effectively to raise their voices in the community about an issue that concerned them.

Data Analysis

The data I collected highlighted significant patterns which greatly aided the subsequent analysis and coding phase of my research. The triangulation of data derived from the students' journal reflections, questionnaire responses and interview answers provided credibility and trustworthiness to my conclusions (Mertler, 2020). I used Mertler's (2020) inductive analysis technique of "organise, describe, interpret" (pp. 305-311) to code the data and used computer software such as Excel for organisation, and Transkriptor for interview transcription purposes. From my analysis, four pivotal themes emerged regarding the power of collaborative action, confidence-building through collaborative relationships, improved collaboration through communities of practice, and increased confidence to participate in community action.

Discussion of Findings

Fluid and Inclusive Collaborative Dynamics Maximise the Power of Environmental Action Plans

By using Gillies' (2020) guidelines for assigning the groups (i.e. smaller groups of 4-6, mixed abilities, presence of established friendships) with no further intervention, I found that my data supported Gillies' projected outcomes for collaborative success (i.e. positive interdependence, individual accountability, promotive interaction and group processing). Student A spoke about her previous experience collaborating on school projects as being "very focused on collaboration, but it was always like somebody needs to pick an idea, and then the rest of the group needs to follow along and do that," which she said, "restricts us." When describing her experience in this project, she stated that "we don't really have … a leader as such, because, like we're just like, Oh, we're all doing it together. We all need our ideas. We all need to speak up… we are all team leaders." Student B said she had not enjoyed collaboration very much in the past as she had always been labelled "bossy" by her peers. The fluid and inclusive collaborative dynamics allowed her to "feel more comfortable sharing my own ideas and thoughts with other people without the fear of getting judged."

Over time, I observed many of the girls volunteering to undertake roles in their groups as their confidence grew. I noted that the planning phase was very much a group effort; then, during the actioning phase, the girls naturally began to assign and take on roles, which allowed them to activate their plans in the community more effectively and confidently.

Confidence in Collaboration Skills Fosters Positive Interpersonal Relationships

Many girls expressed their excitement at "getting to know each other" and being "on the same team," which filtered into other aspects of their school life. Student C expressed that she had made "so many new friends in class" and that the project has "positively impacted other areas such as [when] we're in other classes, like they say, "Can I sit by you?" Because … you just got common ground to really go off." I observed that many of the girls' interpersonal relationships flourished with the fluid group dynamics facilitated by systems thinking, rather than relying on rigid individual roles.

When asked about the ways in which they believed their collaboration skills had developed, Student D stated, "this has developed my collaboration skills a lot because I had to socialise with my group making me cooperate and feel more confident." Student E wrote that "this project has helped me learn how to better collaborate with others to not only find my own voice in a team, but uplift others and give them confidence." These comments highlight the paramount significance placed on relationships between the girls, which fostered their ability to eliminate silos, see different viewpoints, and remain focused on the big picture of environmental action.

Modelling Systems Thinking Through a Community of Practice Enriches Collaboration Between Groups

The goal of setting up the community of practice was to ensure that each group's environmental action plan had the greatest possible reach and impact, and I observed that the groups were eager to exchange assistance. For example, one group discovered that their fundraiser action plan

could not take place on school grounds, so they asked their community of practice for support. Their classmates offered to fundraise at their choir sessions, sports team practices, and parents' workplaces. During an interview with this group, Student F stated that through the community of practice, "it felt a lot easier to … come up to the front of the class and be like, hey guys, so we need a little help here? And then everyone was just so willing." Student D expressed "I think that [my confidence] has gone down a little bit after like we couldn't really sell as much … But now it's going up again, knowing that we have … a whole team backing us up."

Operating within the community of practice allowed many of the girls to visualise how systems (or in their case, groups who are planning environmental action plans) can affect each other and be integral to one another's success. Student G stated in the exit survey that in future collaborative projects, she would like to keep "thinking about the wider community of practice and that having a pool of shared knowledge is a useful 'safety' cushion to fall back on and bolster our action plan." Student H expressed that "systems thinking was the core of our project" and that through connecting with their group and their community of practice, they felt they were "able to create an environment that welcomed a multitude of perspectives, opinions and beliefs to take a more holistic approach to solving the issues" in their action plan.

Using a Collaborative Systems Thinking Approach Empowers Girls to Raise Their Voices in Their Community About Environmental Issues

The data were also reviewed to understand how this project empowered the girls to feel confident to engage their community in a discourse around environmental issues that concern them. This ties in with Brien's (2017) idea that fostering girls' sense of a "science identity" will encourage them to contribute more freely to discussions and actions that affect them. During the exit survey, when asked how they would rate their confidence in sharing their knowledge with their families and communities, on a scale of 1 (not at all) to 5 (extremely), 28 out of 28 students indicated they felt confident, with 21 out of 28 students scoring their confidence level as a 4 or higher. When asked to rate their understanding of *kaitiakitanga* and their responsibility to spread awareness, 28 out of 28 students indicated a positive growth in understanding, with 25 out of 28 students scoring 4 or higher.

Most girls became aware that their actions in their community had the potential to create changes they wanted to see. Student I stated specifically that "using systems mapping really helped me and my group become more confident about what aspects of our community will positively affect the creek the most." Student G signed off on the survey by saying "I think this was an amazing experience that helped me grow in confidence while educating the wider community about a stream that isn't well known." I observed that many of the girls enjoyed the idea that they could be viewed as the experts on this issue in their community, and they took pride in spreading awareness and educating others about the waterway and its health.

Conclusions

The findings from my action research show that the girls, aged 14-15 years old, demonstrated increased confidence in raising their voices as collaborative *kaitiaki* when presented with the opportunity to learn through systems thinking and participate in a community of practice. Having the agency to choose their own collaborative dynamics and to offer assistance and support to one another in the planning of their environmental action plans demonstrated to the girls that they can effect change in their community and raise awareness around issues that concern them. They clearly voiced their enjoyment of being involved in real-world action and using their science knowledge to view the waterway, its ecosystems, and the community around it as a holistic whole. The girls used systems thinking and their connections with each other and community experts to plan the most effective environmental campaign and were able to efficiently work together to bring their plans to fruition, even when faced with obstacles.

Empowering the Year 10 girls to raise awareness in their community as *kaitiaki* had an overall profoundly positive impact on their confidence as collaborators and scientists. However, the limitations of this project were threefold. The first limitation was that there were several students who left to go on holiday during term time and therefore several groups ended up having fewer members than others, which interrupted the flow of the data collection, and meant that my final questionnaire was answered by fewer students than I had originally started with. The second limitation was that the research period had to be carefully divided into time dedicated to the project and time dedicated to their study for their final exams. This was due to the time of the year during which this project was conducted, which did not allow for the entire seven-week period to be solely focussed on their development of their environmental action plans. Lastly, it was difficult to measure the full impact of this project on girls' confidence as environmental guardians due to the limited timeframe. I believe the data set could have been improved with a longer period of observation and research.

Mertler (2020) states that action research can be "organised and facilitated in such a way as to promote more systemic types of improvements" (p. 56) when approached as a collaborative venture in schools. Reflecting on this and the positive impact this project had on the girls in my science classroom, I have begun planning with my department to fully implement this project as a ten week topic in the Year 10 science curriculum over the next year, and with other departments in the school such as Technology, Art and Business Studies to implement the project as a cross-departmental topic for our Year 10 cohort over the next five years.

The school is also supportive of my endeavour to track the participating girls as they progress into their senior secondary school years and to collaborate with our careers department to monitor their chosen career paths as school leavers. I will also be observing which extra-curricular activities they involve themselves in and how they use their voices in the community going forward with the opportunities afforded to them through school life. This will be instrumental to providing myself and the school insights into how the approaches used in this action research project empower *mana wāhine*

who are “confident, robust, optimistic, proud citizens of Aotearoa New Zealand, equipped for global success” (Stanley & Westlake Girls High School, 2023).

Reflection

As a science educator, I have always been passionate about empowering girls to pursue their interests in STEM subjects and contribute to the changes and innovations they wish to see in their community and the world. There have been so many wonderful highlights to this experience, and to see the girls tackle this project with such vigour and be so willing to assist and encourage one another during times of triumph and hardship has been more rewarding than I can express.

I have many people to thank for these past two years, and I would like to start by thanking Natalie Demers, Margot Long and ICGS for introducing me to this method of research and for giving me the opportunity to strengthen my practice in such a profound way.

I would also like to formally thank Westlake Girls High School for supporting me as I carried out this project in my classroom and for providing space for me to present my findings to our staff and to educators all over the world. I am especially grateful to the principal of Westlake Girls High School, Jane Stanley, and Deputy Principal, Sarah Hooper, for thinking of me when applications to join this cohort opened - I had only been at the school for a year and their belief in my abilities has been so appreciated.

My deep gratitude goes to my science department leaders, Alwyn Nicol and Deborah Cachopa, who offered their services as my sounding boards, relievers, and cheerleaders whenever I needed them. Their support has been invaluable, and I am so fortunate to work in such a caring team.

Next, I would like to thank my incredible research advisors, Debbie Hill and AnnMarie Zigrossi. I am very grateful for all of the time, energy and patience that they have shown me while providing robust feedback and encouragement. To my GARC 23-24 fellows, I feel very honoured to have been on this journey with you and I look forward to following your careers as you progress beyond this experience!

A huge thanks to my beautiful family - my husband, Thomas, and our two wonderful sons, Louis and Elliott – for their endless love and support. I am so proud to make you proud.

Finally, to my Year 10 Science class – your strength, passion and eagerness to learn was incredible to witness and I am truly grateful to have been your teacher. It was wonderful to experience and learn it all beside you! You will all go on to do great things.

References

Bolstad, R. (2020). Opportunities for education in a changing climate: Themes from key informant interviews. *New Zealand Council for Educational Research.* https://doi.org/10.18296/rep.0006

Brien, S. C. (2017). *Citizen science: Opportunities for girls' development of science identity* [Master's thesis, University of California, Davis]. ProQuest Dissertations and Theses Global.

Gillies, R. (2020, March 9). An introduction to cooperative learning. The Education Hub. https://theeducationhub.org.nz/an-introduction-to-cooperative-learning/

Heke, I., Rees, D., Swinburn, B., Waititi, R. T., & Stewart, A. (2018). Systems Thinking and indigenous systems: Native contributions to obesity prevention. *AlterNative: An International Journal of Indigenous Peoples*, 15(1), 22–30. https://doi.org/10.1177/1177180118806383

Hipkins, R. (2021). *Teaching for complex systems thinking*. NZCER Press.

Kapucu, N. (2012). Classrooms as communities of practice: Designing and facilitating learning in a networked environment. *Journal of Public Affairs Education*, 18(3). https://doi.org/10.1080/15236803.2012.12001701

Mertler, C. A. (2020). *Action research: Improving schools and empowering educators* (6th ed.). SAGE.

Orgill, M., York, S., & MacKellar, J. (2019). Introduction to systems thinking for the chemistry education community. *Journal of Chemical Education*, 96(12), 2720–2729. https://doi.org/10.1021/acs.jchemed.9b00169

Rangitoto Observer. (2023, December 8). Science project shows creek's worrying condition. *Rangitoto Observer*, 6. https://rangitoto-observer.co.nz/wp-content/uploads/2023/12/ISSUU_RangitotoObserver_8Dec2023.pdf

Stanley, J., & Westlake Girls High School. (2023, January 26). Westlake Girls High School Strategic Plan. https://www.westlakegirls.school.nz/vision/

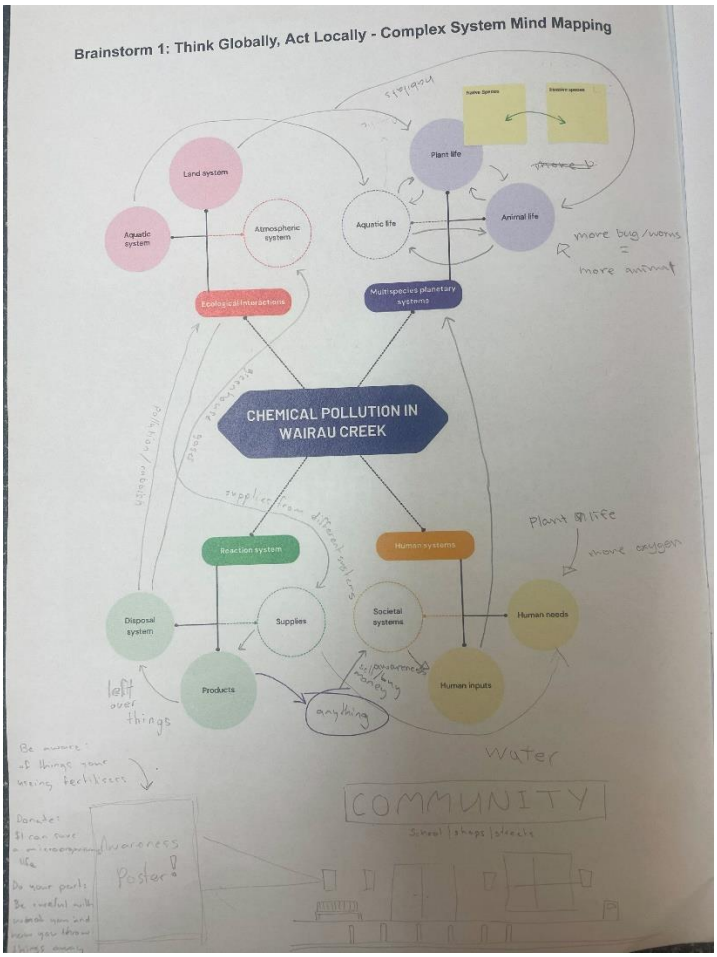
Trott, C. D., & Weinberg, A. E. (2020). Science education for sustainability: Strengthening children's science engagement through climate change learning and action. *Sustainability*, 12(16), 6400. https://doi.org/10.3390/su1216640

United Nations. (2023). *The 17 Sustainable Development Goals*. United Nations. https://sdgs.un.org/goals

Apprendix A

Example of student systems thinking mind map using template

Students learned about the systems affecting Wairau Creek and mind-mapped these concepts using a template provided in their planning journals



Appendix B

Examples of student environmental awareness campaigns

One group of girls wrote to a local newspaper to raise awareness about Wairau Creek in the community, while another produced eye-catching posters featuring QR codes that take the scanner to their letter to the local member of parliament.

Water wise... Year 10 science-extension students (from left) Hannah Smith, Gabeen Sim, Limin Khaw, Tanisha Pandya, Alice Oh and Science and Chemistry teacher Alex van der Loos with the testing kits they used to collect data from the Wairau Creek and awareness posters they made to inform the community about the importance of the waterway

From "Science project shows creek's worrying condition" (Rangitoto Observer, 2023, p.6)

Appendix C

Students participating in testing the water quality of Wairau Creek

The students were taken to Wairau Creek by a local community expert from the Wai Care programme through Auckland City Council and used comprehensive water testing kits to see the results first-hand.