Environmental Citizen Science and Action in Hong Kong Schools

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Abstract

My research investigates the impact of citizen science experiences on Hong Kong students' values, attitudes, knowledge and behaviour towards the natural environment. This study intersects citizen science, environmental and experiential education, environmental behavioural psychology, and citizenship action. My aim was to examine citizen science as a pedagogical tool to influence greater youth agency to tackle environmental issues. This investigation evaluates the impact of school-based citizen science, addressing known research gaps. Increased environmental knowledge from citizen science is well established in the literature from western studies, though less is conclusively known about its impact on values, attitudes and behaviours, especially from an Asian perspective.

Using a quasi-experimental mixed methods approach, I engaged with citizen science organisers, and teachers and students from eight schools in Hong Kong. Informed by environmental behaviour psychology, and environmental and experiential education theories, I modified an environmental behaviour model as my theoretical framework to guide the design of survey and semi-structured interview questions. My analysis is based on pre- and post-surveys from 187 students, and interviews with 46 students, 18 teachers and four citizen science organisers.

My findings suggest that citizen science experiences lead to increased environmental knowledge and self-reported pro-environmental behaviours, with a moderate positive correlation between behavioural intention and behaviour. Pro-environmental behaviour is most influenced by field trips and personal experiences in natural environments, one's connection to nature, and being exposed to environmentally positive actions. This illuminates the importance of 'nurture in nature for nurture of nature'. Teachers, students and citizen science organisers shared similar impressions about the value of environmental education and citizen science but differed about where and how citizenship action was incorporated in environmental education. My findings provide evidence about how to use citizen science as a catalyst to enhance environmental education and narrow the value-action gaps in Hong Kong youth.

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Abbreviation	Definition
2-MEV	Two-Measurement Environmental Values
AFCD	Agricultural, Fisheries and Conservation Department
AI	Artificial Intelligence
CAS	Creativity, Activity, Service (within the IBDP)
COP	Conference Of the Parties
DSE	Diploma of Secondary Education
GCD	Global Citizenship Diploma
GCSE	General Certificate of Secondary Education
GDP	Gross Domestic Product
HK	Hong Kong
HKISCNC	Hong Kong Inter School City Nature Challenge
HKSAR	Hong Kong Special Administrative Region
HKDSE	Hong Kong Diploma of Secondary Education
IB	International Baccalaureate
IBMYP	International Baccalaureate Middle Years Program
IBDP	International Baccalaureate Diploma Program
IGCSE	International General Certificate of Secondary Education
ISO	International Organisation for Standardisation
MDG(s)	Millennium Development Goal(s)
MPA(s)	Marine Protected Area(s)
NEP(C)	New Environmental Paradigm (Children)
NGO(s)	Non-Governmental Organisation(s)
NSF	National Science Foundation
PARRISE	Promoting Attainment in Responsible Research and Innovation
PS statistic	Probability of Superiority statistic
Q&A	Question and Answer
RISE	Recognizing Industrial Smoke Emissions
SDG(s)	Sustainable Development Goal(s)
SEI	Stockholm Environment Institute
SO_2	Sulphur Dioxide
SSI(s)	Socio-Scientific Issues
SSIBL	Socio-Scientific Inquiry-Based Learning
TPB	Theory of Planned Behaviour
U.K.	United Kingdom
UKRI	United Kingdom Research and Innovation
UN	United Nations
U.S.A.	United States of America
VIF	Variance Inflation Factor
WWF	World Wide Fund for nature

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Dedication

To my Family, past and present: I have sat in your ‘go-dee’ (lap) when I was little and have stood on your shoulders as I grew up. You are the springboard for everything I do.

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Author's Declaration

I declare that this thesis is a presentation of original work carried out by me, and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as references.

CHAPTER 1

1 Introduction

1.1 The Anti-Inspiration

Armed with black garbage bags, we marched across a Hong Kong (HK) beach to recover trash washed upon the wrack line. Styrofoam containers, flip flops, fishing nets, plastic bottles, straws and bags were our most common targets strewn amongst the seaweed and sand. Joining forces to make light work of a beach clean-up across a 300m stretch of remote coastline, students and teachers remarked on the quantity and range of debris collected in under 30 minutes. We were practising the 'leave no trace' philosophy at the end of our two-day geography field trip and felt virtuous about leaving our campsite better than we found it. As we carried the brimming bags to the garbage collection site, I asked my students nearby what the first thing they wanted to do was, when they got back home.

"Go for bubble tea!", they chirped.

Bubble tea? After all that sifting of sand for plastic rubbish, they wanted to buy something served in a take-away plastic cup, with a plastic lid and a plastic straw? I couldn't resist sharing my query with them. They all promised they would recycle the containers, and one even pledged to reuse it many times before eventually putting it in the recycle bin. They knew I was sceptical. I was hoping that seeing the issue with their own eyes and cleaning it up with their gloved hands would have brought the marine pollution problem closer to home, and maybe even shifted behaviours. But I was not surprised when after one lesson with a reused bubble tea cup filled with drinking water on that student's desk, I did not see it again.

Why don't people always act on the values they hold dear?

This question grew louder over my 13-year career teaching geography and world issues in international schools in Hong Kong. I believed in the transformative power of experiential education because of the insightful conversations I had with my students during our multi-day trips into Hong Kong country parks, Indonesian jungles, Cuban seas and Nepalese mountains. During that time, I was learning about a scientific enquiry and engagement method called citizen science and incorporating such projects into my pedagogical approach. When some students spoke of perspective shifts and intentions to take action, I wondered how much impact such experiential environmental education activities had on them. Citizen science is when experts and the public conduct research about a topic of common interest (I discuss citizen science typologies in Ch. 2.2.2), and the projects my students and I were involved in were about ecological biodiversity.

My PhD research journey was born from a desire to be a more effective teacher by exploring citizen science, environmental education and citizenship action. I wanted to help address the environmental value-action gap I observed; thus, I channelled my study into understanding the impact of citizen science experiences on how students feel, think and act towards the natural environment. This investigation required bridging experiential and environmental education, citizen science, environmental behaviour psychology, and citizenship action to better understand what influences youth behaviour.

1.2 Research Aims

As an educator, I was interested in conducting research with practical outputs for teachers, school administrators and citizen science organisers delivering environmental education to Hong Kong students. These outputs would be in the form of actionable implications and recommendations about how to encourage pro-environmental behaviour through experiential approaches like school-based citizen science. My research focuses on determining how citizen science experiences may have an impact on local and international school students' pro-environmental values, attitudes, knowledge and behaviour towards the natural environment. The study links research and practice within citizen science, environmental education, environmental behaviour psychology and citizenship action. I aimed to understand which psychological variables most influence students to take action after their citizen science experiences. Another aim is to comprehend the varying perspectives of teachers, students and citizen science organisers about environmental education, citizen science and citizenship action. Part of that is to enquire about opportunities and barriers teachers and students perceive when considering taking some form of pro-environmental action. From an academic point of view, the investigation will also provide insight on the use of environmental behaviour psychology frameworks to understand citizen science in a secondary school setting. From a pragmatic pedagogical angle, the findings from my research can inform practice, ideally enhancing how teachers, educational institutions and citizen science organisers engage with youth to apply their learning and take pro-environmental citizenship action about issues that matter to them. Ultimately, my PhD is in service of a professional curiosity to tackle the environmental value-action gap, and a desire to contribute a unique Asian perspective to this nascent area of research.

1.2.1 Contribution of My Study

My PhD research offers original contributions to the bodies of knowledge about environmental education, citizen science, environmental behaviour psychology and citizenship education in three distinct ways. The first is the innovative application of an adapted environmental behaviour framework to empirically measure change and influence of psychological variables on behaviour in youth. After an examination of the evolution of environmental behaviour psychology theories and models in the literature, I chose to modify the environmental values scale and some of the variables in Barr and Gilg's (2007) environmental behaviour framework to suit the current Hong Kong educational context. To my knowledge, this is the first time that their framework has been used in such a setting to measure environmental value-action gaps.

The second meaningful contribution is that my study provides empirical evidence about the impact of citizen science on pro-environmental values, attitudes and behaviours in students, an under-studied topic at the intersection of citizen science and environmental education. While studies about the value of environmental citizen science projects with adults suggest that such experiences can prompt a desire to behave in more environmentally conscientious ways, they mainly measure behavioural intention, not behaviour. Research with students involved in citizen science projects usually report actions that are project-specific, such as talking to others about the project findings, with minimal transfer of pro-environmental behaviours in their daily lives. My research topic is novel in the use of specific items to measure a range of behavioural intentions and self-reported behaviours that span personally-responsible, participatory, and justice-oriented citizenship actions. This bridges citizenship education with citizen science and environmental education; a pragmatic way for practitioners (teachers and school leadership), as well as academic researchers, to conceptualise the value of such an experiential approach with students.

The third way my investigation provides an original contribution is through its socio-geographical context. While attitudes and impact of environmental education have been sporadically studied across Hong Kong educational institutions in the last three decades, this is the first study of its kind that measures the impact of a citizen science experience as part of environmental education in local and international schools. My findings offer practical implications that can be applied directly to the Hong Kong educational system. Furthermore, as most school-based citizen science research has been conducted in North America, Europe and Australia, my findings within an East Asian context go some way to fill the large research gap.

1.2.2 My Research Approach

As an insider-researcher, having been a professional teacher, I embraced a pragmatist research paradigm and opted to use a quasi-experimental mixed methods explanatory approach to determine the impact of environmental citizen science experiences on students. My participants included students and teachers in local and international schools (whom I had never taught or worked with prior to this study), and citizen science organisers working in environmental NGOs and start-up companies in Hong Kong. To suit the Hong Kong school context, I modified an environmental values scale and adapted an environmental behaviour framework created by Barr and Gilg (2007) to develop my quantitative survey and qualitative interview questions. Quantitative data came from matched pairs of online pre-surveys and post-surveys, and qualitative information was obtained from in-situ field observations during the citizen science activities, and online semi-structured interviews generally a few weeks later. Descriptive and inferential statistical tools including Wilcoxon signed rank tests and multiple linear regression were applied to determine change after citizen science experiences, and the quality of influence of various psychological variables on self-reported pro-environmental behaviour. For the qualitative data, reflexive thematic analysis was used to examine the perspectives of teachers, students and citizen science organisers.

1.3 Chapter Summaries

The following chapter, Chapter 2, is the first of two literature review chapters that introduce the pedagogical approaches of experiential and environmental education, and the field of citizen science. I foreground their interrelationships by highlighting the theoretical contributions of key scholars in education and citizen science research. I explore the influential insights of scholars like John Dewey, Paulo Freire and bell hooks to discuss their relevance in environmental education research, as experiential learning and critical engagement often goes hand-in-hand. Connected to this is the pedagogical arena of global citizenship education. In this subsection, I examine prior work of scholars like Vanessa de Andreotti who promote a more critical lens when investigating the efficacy of youth citizenship action. From this context, I raise the opportunities afforded by the citizen science approach with a brief description of its growth as a research and pedagogical tool in the last few decades. Most citizen science projects and research about their impacts are carried out in western contexts with adult participants. For investigations involving youth, the pro-environmental behaviours reported are often project-specific and from measurements usually taken after the activity. Thus, I used a quasi-experimental design to evaluate the impact of citizen science on youth to provide some empirical evidence about the connection between environmental values, attitudes and behaviours, and citizen science. This is a topic with significant implications for those involved in environmental education and citizen science.

Chapter 3 begins by delving into the concept of a 'value-action gap' – what it is and why it is such an important arena for those inside and outside the academic world. I then explore the development of theories and frameworks used by behavioural psychology researchers, including those in the environmental field. By considering early works about what leads people to behave in certain ways, to more recent research about encouraging pro-environmental action, I narrow the focus of academic literature to appreciate how to measure the 'value-action gap'. Through this journey, I justify the relevant environmental scale, framework and theoretical constructs most suited for my novel study, and synthesise the state of environmental policy and education and the use of citizen science in the Hong Kong context, thus creating a natural gateway to the following methodology chapter.

Chapter 4 describes my methodology to explore the impact of citizen science experiences on youth and understand teacher, student and citizen science organiser perspectives about environmental education, citizen science and citizenship action. As an experienced teacher in Hong Kong schools, I have an insider-research position that connects to my pragmatist researcher paradigm. Thus, my professional experience informs the mixed-methods explanatory approach with quantitative and qualitative instruments to determine the impact of citizen science in schools. A quasi-experimental research design meant online surveys were administered to students in local and international schools a few weeks before and after their citizen science project, supplemented by in-situ field observations when possible. To understand viewpoints at greater depth, online semi-structured interviews of students, teachers and citizen science organisers were conducted after the post-surveys. Quantitative data was analysed using descriptive and inferential statistical methods using the IBM SPSS program, while qualitative information was analysed using the reflexive thematic analysis approach to develop codes and themes that reflected the patterns of information shared by participants.

The first of three results chapters, Chapter 5 addresses the first sub-research question, "Do citizen science experiences have an impact on student pro-environmental values, attitudes, knowledge and behaviours?". It begins with a demographic overview of the student, teacher and citizen science organiser participants in my study. The bulk of the chapter is dedicated to description and explanations of the results of quantitative statistical tools. Where relevant, qualitative data is weaved into the analysis to help explain potential reasons for my results. The results are compared using the situational variables of school type, citizen science project type, school level and gender. I report the positive and negative shifts in environmental values, attitudes, knowledge and self-reported behaviour, and reveal the psychological variables that most influence pro-environmental behaviour in students.

Chapter 6, the second results chapter, addresses the second sub-research question, "What are teacher, student and citizen science organiser perspectives about environmental education and citizen science?". Reflexive thematic analysis was carried out on the interview data to understand participant beliefs. I highlight where participants had complementary, as well as more divergent views about the value and goals of environmental education and citizen science. Impressions are mapped using themes and sub-themes to capture the essence of their sentiments, with quotes to provide depth and nuance. The chapter is divided into sub-sections that look at teacher, student and finally, citizen science organiser viewpoints separately, with the sub-section summary providing comparative analyses of all perspectives regarding environmental education and citizen science.

The third results chapter, Chapter 7 shares the results about the third sub-research question, "What are teacher, student and citizen science organiser perspectives about citizenship action and pro-environmental behaviour?". Like the previous chapter, themes, sub-themes and quotes are used to represent the results in sub-sections by participant group. I also delve into the opportunities and barriers for pro-environmental behaviour as experienced by students and teachers, and summarise these findings in diagrams and tables to show unique realities between local and international school systems. A detailed comparison about what effective citizenship action is reveals insightful commonalities and differences between teachers, students and citizen science organisers. I close the chapter with a summary of the level of alignment that teachers and citizen science organisers had with students about citizenship action.

In Chapter 8, I discuss my research results in the context of the wider academic literature. I focus on the unique discoveries that address the overall questions about the impact of citizen science on youth environmental values, attitudes, knowledge and behaviours, and the varying participant perspectives. These revelations are tethered to overarching themes of "Nurture in nature for nurture of nature" and "Where the education system breaks", which in themselves hint at potential implications for policy and practice. In the latter part of the chapter, I offer a critique of the adapted environmental behaviour framework I employed to underpin the research and survey design.

My conclusion, in Chapter 9, synthesises the most meaningful findings about the impact of citizen science experiences on how youth feel, think and act towards the natural environment. I offer answers to the overall research questions by addressing each of the sub-research questions, while making explicit where my research contributes to the field in original and novel ways. My discussion about limitations displays critical reflection about my methods and analytical approach, and my suggested improvements reveal a consideration of how the potential changes would enhance the research outcomes. A significant portion of the chapter is dedicated to the implications from my study and the wider research on practice and policy in the Hong Kong context. I close the chapter, and the dissertation, with opportunities for future research and my reflection about how to strengthen our understanding of the intersection of environmental education, citizen science and citizenship action, and how to address the youth environmental value-action gap.

CHAPTER 2

2 Educating for Change: Theories and Practice

This chapter utilises the most relevant pedagogical theories about experiential, environmental and citizenship education to the specific research approach of citizen science. I explore ideas from experts such as Dewey, Freire and hooks, around the value of reflective and critical approaches in education to impact not only the learner, but the learner's world. Drawing attention to citizen science, I introduce how it is used to engage the public in scientific research, while highlighting the outcomes, opportunities and challenges of such contribution. Making reference to research about the merit of situating one's learning in the real world, the latter parts of this chapter highlight the potential of citizen science in educational settings to align with pedagogical objectives of transformative educational experiences. I apply this context for the use of citizen science in school-based environmental education to propose its capacity to develop agency in youth to act on issues they feel are important.

2.1 The Role of Education to Make the World Better: How Experiential, Environmental and Global Citizenship Education Come Together

Locally and globally, education is held in high regard, so much so that it features as number 4 of the 17 United Nations Sustainable Development Goals (UN SDG). Goal 4's targets not only highlight equal access for all and across primary to tertiary education and vocational institutions, but also declare the need for quality education that emphasises sustainable development and global citizenship education (Sustainable Development Goal 4; UNESCO, 2017). Such frames for educational contexts are not new. The 1977 UN Tbilisi Declarations, focused on defining the role and objectives of environmental education at the local and global scales (United Nations Environment Programme, 1978), long predate the 2015 implementation of these current UN goals. Educators and academics have long recognised the importance of pedagogy that values critical thinking about the social, economic, environmental and political forces at play in one's realities and the skills needed to change circumstances for the better (Bencze & Carter, 2011; Bourn, 2016; Brown, 2018; Andreotti, 2014; Dirkx et al., 2006; Freire, 1974; Miettinen, 2000). This section of the chapter discusses the merits of the constructivist learning elements within experiential education and transformative learning considering this movement. It delves into those approaches' complementary characteristics which relate to the positioning of education as a force for social and environmental change.

2.1.1 How Experiential Education Can Spark Transforming Oneself and One's World

For an experience to be educational, it requires meaning to be attached to it. This is a fundamental tenet of John Dewey's expression of experiential education, as just "mere activity does not constitute experience" (Dewey, 1916, p.163). The greater consciousness associated with recognizing that one has undergone an experience involves a manner of reflection, which Dewey suggests is akin to thinking or pondering, and is very much an act that can happen before, during or after an activity (Ord, 2012). Learning through experiences is a dynamic way to engage with one's world and can be described as a 'transactional' process, whereby as one affects their environment during an experience, they too are affected by their experience (Dewey, 1916). The 'environment' that Dewey often referred to was the learners' community around them, though Orr (1994) remarked how Dewey's notions included the school area, as well as nearby natural environments. Dennis and Knapp (1997) argued that Dewey acknowledged how experiential education also involved learning about the interconnectedness of nature and people, and thereby bridged experiential with environmental education. The feedback effect of the 'transactional' process was an idea Dewey (1925) returned to in 'Experience and Nature', where he proposed an experiential approach to better understand nature, which in turn, enhanced one's experience and made an impact. Impacts can be upon one's values and beliefs or about the significance of the experience outcomes, amongst many other possibilities; all of which come to light upon reflecting consciously about the learning that took place. These key attributes underpinning experiential education are fundamental to Mezirow's and Dirkx's ideas (in Dirkx et al., 2006) about how transformative learning can take place.

To recognise that a change has occurred, one would need to be aware of one's state prior to the experience. This is where Mezirow insists that a consciousness and critical thinking skills are required to record a shift in one's frame of reference, a set of ideas based on values, beliefs and perspectives that guide us in seeing the world in a particular way (Dirkx et al., 2006). Dirkx on the other hand suggests that the 'outer world', a more cognitive and social space, plays as much a part in shifting mindsets, as does the 'inner world', a more private place of emotions that may not always be well understood. Despite their differences in considering how the transformation takes place, Mezirow and Dirkx agree that learning can happen unconsciously, and that the aim of transformative learning is to challenge the protocols that allow people to think and act the way they do, and to help them change, if they so choose (Kitchenham, 2008). Dirkx et al. (2006) argue that this focuses the learning on not only the outcome, but the process as well, which ultimately leads to an evolution of mindsets and behaviours.

These pivotal developments hint at Paulo Freire's priorities in "Education for Critical Consciousness" (1974), where he links critical thinking and critical action. Though framed within the backdrop of development and inequality in South America after the 1930s Great Depression, Freire's concepts about the power of effective education to build capacities in people (who he describes as 'subjects' and not 'objects') to influence their world and build democratic societies, is just as attractive today. In Freire's (1974) perspective, 'objects' are the people who merely adapt to their situations, while those who have the critical thinking power to change their realities are 'subjects', since they are the ones taking action. I would argue that viewpoint is mirrored in Shaw's (1904) 'Man and Superman', where he writes, "the reasonable man adapts himself to the world: the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man" (p.238). Thus, the duty of an educator is to facilitate the growth in consciousness of the 'subject' to become someone with the critical capacity to influence their world.

To aid educators in this regard, the learning theory of constructivism has gained much acclaim and use in experiential and environmental education (Klein and Merritt, 1994; Robertson, 1994; Arik and Yilmaz, 2020). The core element of a constructivist approach revolves around the learner creating their understanding based on stimulus and then contextualising that learning based on earlier constructs of that knowledge as they experience it (von Glaserfeld, 1995). As learners experience the world around them, they are building their understanding of phenomena through their social and mental processing, which is an active form of learning (Klein and Merritt, 1994), one that aligns with Dewey's ideas about learning by doing. Though they were describing constructivism in the context of mathematics education, Clements and Battista (1994) summarized the following underlying principles, which have great parallels with experiential and environmental pedagogies: (i) the learner actively creates their knowledge; (ii) reflections help develop new knowledge; (iii) learning sticks better when it can fit with a context that respects prior knowledge; (iv) the social learning context is part of the knowledge-development process. These principles align with ideas that are important in contributory and especially co-created citizen science activities. A recent meta-analysis study quantitatively reported higher effect sizes for environmental education achievements when using a constructivist rather than a traditional (didactic) learning approach (Arik and Yilmaz, 2020). Experiential education as a pedagogical approach shows much promise as a strategy to make learning meaningful, transferable and transformative, for oneself and the world they encounter.

2.1.2 How Education for Sustainable Development, Environmental and Science Education Links to Thinking and Acting Critically

Educators who aim to empower others to be agents of change often share Freire's beliefs about the value of each individual if they are given the opportunity to act. Education has a great role to play in helping communities address some of the most challenging issues of our time, like climate change for example (Mochizuki & Bryan, 2015), as it compels considering one's personal actions and impacts on others. This is, in fact, one of the specific learning objectives published in UNESCO's guide about education for sustainable development (UNESCO, 2017). The global guidelines not only touch upon the cognitive, but also the socio-emotional and behavioural facets of educating for sustainable development, bridging opportunities for knowledge, empathy and action. While well-meaning, aspects about the focus of the learning objectives have been called into question. Glackin and King (2020) evaluated the landscape of environmental education in the English National Curriculum and found it to be disproportionately focused on learning *about* the environment. A similar situation exists in Hong Kong, where curricular documentation revealed content knowledge-building to be a priority, rather than engaging students in learning *for* and *in* the environment (Ma, 2016; Ma, 2019). Education for sustainable development, the pedagogical connection to the UN SDGs, has links with the goals of environmental education. Broadly speaking, the main aims of environmental education are to increase environmental knowledge, impact environmental values and influence positive environmental behaviour to solve environmental problems (United Nations Environment Programme, 1978). However, as sustainable development maintains an economic growth model while resorting to limits for negative environmental impact, it can sometimes be at odds with such pro-environmental goals from a critical perspective (Stevenson, 2007). Even when educators want to design more experiential opportunities for students to apply their learning by taking action, barriers such as a lack of planning time, insufficient professional development and limited resource support from school administrators, are often cited (Ernst, 2007; Monroe et al., 2016). The challenges to apply the well-intentioned UNESCO guidelines in education for sustainable development even permeate into the realm of socio-economic politics.

Bencze and Carter (2011) describe the efforts to implement change in the educational system as trying to overcome powerful inertia of the neoliberal forces that prefer to develop ‘producers’ and ‘consumers’ to maintain the current socio-economic state. Bencze and Carter (2011) and Hodson (2003), amongst others, describe how science education, in particular, has fallen victim to the values of industrial and commercial interests, such that what students are learning in schools supports the Western cultural norm of consumerism. For example, educational bodies which design curriculum underscore the importance of scientific literacy in a global technological future where people lead productive lives and careers, thereby contributing to their techno-scientific world (Bencze & Carter, 2011; Hodson, 2003). Locally in Hong Kong, the overarching aim of the local secondary school course, Integrated Science, is for “students to develop scientific literacy, so that they can participate actively in our rapidly changing knowledge-based society, prepare for further study or a career in fields where a knowledge of science will be useful; and become life-long learns in science and technology” (Education Bureau, 2021). This objective has little indication or guidance for critical evaluation of how the science and technology information is being used in the students’ lives.

Pressure to limit teaching to the curriculum (for maximising exam achievements) at the cost of more engaging pedagogical approaches like debates and critical inquiry, is a constraint embedded within many educational systems (Dunlop et al., 2020). Disrupting the system that emphasises profits and power, over the well-being of all people and the planet, and repositioning education as the conduit for driving change, has been the call for years (Bencze & Carter, 2011; Dunlop et al., 2020; Kirsop-Taylor et al., 2020; Levinson, 2010; Reid et al., 2021). Some suggest that it is the duty of educators to practice 'classroom resistance' and recognise the role that real-world contexts can play in their lessons to enhance student competences (Bazzul & Tolbert, 2019; Bencze & Alsop, 2014; Bourn et al., 2017).

Going even further, bell hooks invites educators who use the engaged pedagogy approach to ideologically shift the curriculum "to make their teaching practices a site of resistance" (hooks, 1994, p. 21). A part of this approach relies on the learner's ability to think critically, and by thinking critically, they transcend the foundational knowledge about the topic to consider its importance, prompting the questions, 'why care?' and 'what now?'. This way of 'thinking as action' (hooks, 2009) is key to developing a learner's skills to apply their education for the betterment of their world. Her philosophy dovetails quite neatly into the realm of environmental education, where one of its main goals is to use one's knowledge to take action and address environmental issues affecting one's life.

Schusler and Krasny (2015) suggest how environmental action is at the centre of where science education and civic education overlap, with greater youth-driven inquiry being at the core of how to apply one's learning to influence positive change in one's community. In the context of my research, I use the terms 'action' and 'behaviour' broadly without differentiating between activities people do habitually compared with deeds that require great effort and planning. Having a wider definition meant I could incorporate the opportunities for individual and collective endeavours towards positive change, as there is a growing call that both approaches are concurrently needed to address the large-scale problems of society (Ariza et al., 2021; Koskela and Paloniemi, 2022).

Putting ideas into practice, Calabrese Barton (2003) demonstrates the influence of a more critical studies approach in her informal science educational experience with marginalised urban youth. The focus was on using scientific knowledge and skills for a purpose (to solve a community need), and thereby go beyond learning scientific content. The students in her study were 'practicing science' rather than 'doing science' to positively impact their reality, and subsequently felt heard and valued by their community, despite their socio-economic status. In a review of the literature that critically considers the mainstream approach to teaching science, Bencze and Carter (2011) argue for greater opportunities for action based on student inquiry, which resulted in the development of a framework titled 'Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments' (STEPWISE). It incorporates a recognition of the contexts of culture, power and politics in the pursuit of research into socio-scientific issues (SSIs). The STEPWISE framework assists middle and high school teachers and students to learn scientific content in the context of science & technology and societies & environment (STSE). Its ultimate aim is to encourage activist science students and support research-led actions that range from changing one's own behaviour, to building awareness campaigns, to engaging with socio-political stakeholders to address fundamental causes of issues being investigated (Bencze & Alsop, 2014). Another example of a critical approach to teaching and learning in science was the 3-year European project called "Promoting Attainment in Responsible Research and Innovation" (PARRISE), that offered training for experienced and pre-service teachers in SSI inquiry-based learning (SSIBL). PARRISE used a simple model of "Ask → Find Out → Act" to structure opportunities for teachers and students to engage with issues of concern in their respective communities and ultimately, consider a solution worth enacting (Amos & Levinson, 2019).

There is, however, hesitation in these kinds of approaches by practitioners and students alike. There can be potential institutional or peer backlash when engaging with controversial or political issues (Bourn, 2016; Dunlop et al., 2020). Some practical barriers include the complexity of the frameworks like STEPWISE and its realistic implementation in a classroom setting (Bencze & Carter, 2011), as well as the time it takes to stay abreast of current affairs (Amos & Levinson, 2019). Though the teachers who took part in the PARRISE training report success in maintaining interest and keeping the lessons relevant to their students, the challenge to go beyond researching facts and presenting their findings to school leadership was a common concern. Evaluating how much personal action was being taken, considering perceived resistance from peers or the community, was yet another layer of difficulty in understanding the direct and lasting impact of the SSIBL approach on students (Amos & Levinson, 2019). Educational theorists that value reflection, like Dewey and Mezirow, would argue that a significant element of the linear SSIBL approach is lacking, which may help to unlock opportunities and motivation for deeper engagement and action (Dirkx et al. 2006; Miettinen 2000). Despite these objections, I would argue that it is important to use critical approaches in teaching and learning, especially for disciplines like science and environmental education with the aim to take action. The reluctance to act is reminiscent of Freire's (1974) theory of "conscientização", critical consciousness to act against oppressive systems, and precisely why there is growing concern about how opportunities for action are framed and taught. Exercising one's ability to think deeply and widely, with a critical eye, is already an act (hooks, 2009). It is a statement to inform oneself and one's peers what is well and not well with the world, and what to do next.

2.1.3 How Global Citizenship Education Can Give Shape to Acting Critically

With the proliferating implementation of environmental and science education, alongside education for sustainable development, there are strong voices that are asking what it means to be an effective global citizen and how to create social change (Brown, 2018; Andreotti, 2006, 2014; Westheimer and Kahne, 2004). The following paragraphs introduce what global citizenship education is, what it should not be, and how it relates to reflection and critical thinking, and share a particular categorisation of global citizen characteristics I use to analyse pro-environmental behaviours of my participants.

Educators and youth are exposed to global citizenship through formal educational curricula, for example, the Global Citizenship Diploma (GCD, 2020), as well as from non-governmental organisations (NGOs) that are concerned with educating for social and environmental justice (Andreotti, 2006). Global citizenship education, at its core, is about viewing the world with a critical lens to understand the forces that have led to past and current situations for the planet and its people, and more usefully seen as a pedagogical tool than a subject in itself (Xing, 2015). The plethora of resources and stimuli are useful tools in engaging people in real-world issues, with the potential to initiate actions for change. However, there is a danger that a mindset of 'saving the world' may be imprinted on the public, which may be problematic despite good intentions (Bryan, 2013). That outlook can be laced with embedded cultural and political messaging, whereby people presume that a need exists and decide to take on the heavy task to civilise or educate the less fortunate (Andreotti, 2006). These sentiments mimic the power dynamics akin to past colonial perspectives and must be avoided for citizenship education to be of value to the learner, and Andreotti (2014) offers how by differentiating 'soft' and 'critical' citizenship education. Again, the importance of reflection (as highlighted by Dewey, Mezirow and Freire, and within the constructivist learning principles) along with the development of critical literacy is key for learners to understand their own mindsets and perspectives when analysing a particular issue (Brown, 2014; Davies & Evans, 2002; hooks, 1994, 2009). Engaging in the challenging task of critically considering one's own position amidst the societal forces that shape realities, brings to the fore that education can never be neutral. The curriculum and tools associated with global citizenship education are understood to have a particular agenda - to transform the world while being transformed ourselves (Brown, 2014). This agenda is influenced by a community's socio-cultural context and their priorities to encourage certain types of citizenship engagement and to develop particular kinds of citizens (Brown et al., 2021).

Additionally, Andreotti (2006) argues that the motivation for action and responsibility should come from a sense of justice, rather than from a seat of pity. A study involving interviews of educators and participants in informal educational activities organised by Spanish and British NGOs by Brown (2018) found that there was a more profound impact on participant learning when they engaged in their own research of the complex root causes of issues. The educators in the study also saw these experiences and reflective discussions as ideal primers to initiate collective action, and the longer the time frame of the activities, the greater the networks, the strength of the relationships and the ability to engage with the multi-faceted issues. Brown's (2018) research highlights the roles that NGOs can play in defining what good citizenship looks like, and how creating networks of committed people can lead to forms of social change. In a similar vein, there are opportunities at the intersection of global citizenship education and education for sustainable development that spark reflection, criticality and action through collaborative teaching practices and research, to develop one's agency (Khoo & Jørgensen, 2021).

One way to spark agency could be that NGOs and educators share a list of possible actions people can engage with in response to an issue of concern. While this approach may seem somewhat simplistic and be at odds with the criticality of learning approaches mentioned earlier in this chapter, it is not necessarily a limitation that stifles agency, as noted by a 2-year mixed methods study by Westheimer and Kahne (2004). Their results from surveys, observations and interviews of Grade 12 (17-18 year old) Social Studies students and their teachers led to the categorization of three forms of a 'good' citizen: (1) personally-responsible citizen; (2) participatory citizen; and (3) justice-oriented citizen. These forms highlight the differing objectives and implications that educational programs would need to have if catering to particular citizenship profiles (see Table 1).

Personally-responsible	Participatory	Justice-oriented
A citizen who takes personal action to support issues that matter to them, within the constraints of the community system (e.g. recycling, donating to a food bank, buying local seasonal and fairtrade produce)	A citizen who actively engages in civic life by taking the lead in organising community-based events (e.g. running the recycling campaign, organising the food drive, being the voice of a local NGO looking for donations)	A citizen who critically sees the complex root causes of an issue in the community and explores collective strategies to challenge the injustice in the first place (e.g. activism and engagement with local councils to build programs that address hunger or homelessness in their community)

Table 1: Three types of citizen profiles, and examples of actions they would take (from Westheimer and Kahne, 2004)

One could argue that the personally-responsible citizen, who follows the rules to do good, may not be Paulo Freire's poster-child for an effective 'subject', and Westheimer and Kahne (2004) found that just because one could speak eloquently about the intricate problems at the core of an issue affecting their community, it didn't necessarily mean that those students were prompted to take more action about it. Statistical tests between a control group and one where students were engaged in participatory citizen activities demonstrates the point that one could successfully engage in collective action without examining the issue at depth. "Youth in Public Service", one of the programmes studied in the eastern United States, wanted students to effectively engage with their community and address a local need (Westheimer & Kahne, 2004). That goal was met as the students presented their research and action plans to their county's Board of Supervisors, resulting in a boost in self-confidence, the development of practical skills and the enthusiasm for more civic engagement. This was achieved despite the students not going into the details of why some of those community issues persisted in the first place. This touches upon the complex nature of what motivates one to act, and research in the behavioural sciences, which I discuss in more detail in the next chapter (see Ch. 3), suggest that knowledge isn't enough (Barr, 2006; Ajzen, 2012). There were differences between the participatory citizen and justice-oriented citizen programmes; the students in the latter programme showed a statistically significant increase in their sense of civic agency (Westheimer & Kahne, 2004). Westheimer and Kahne (2004) note that differing priorities, time constraints and curriculum structure would impact the type of programmes that schools can offer, however they advocate that this type of experiential education is a greater driver for attitude and behavioural change than if students were given a list of actions to address issues of concern in their communities. These findings contribute to the framing of different kinds of citizens and citizenship action in my study, and prompts exploring the impacts of the more inquiry-based co-created citizen science approach, compared with the contributory type of citizen science.

For educators who want to instil a sense of curiosity, critical consciousness and nurture the skills to collaboratively address the socio-economic, environmental and political challenges of our time, there is an opportunity to use a research and action method that is gaining popularity by researchers and participants alike: citizen science. Davies (2004) makes a case to explore further opportunities where citizenship education and science education converge to enhance deeper debate and reflection, and consider action. While Davies (2004) focuses on science, citizen science projects can be integrated into a variety of school subjects where such a research approach benefits student learning or opportunities for service learning (Tsueng et al., 2019). Seeing the intersections between global citizenship education and education for sustainable development (Khoo & Jørgensen, 2021), using citizen science as a pedagogical tool to learn about sustainable development revealed gains in learner motivations and enquiry skills (Rodríguez-Loinaz et al., 2022). Wals et al. (2014) offer how citizen science could act as a bridge between science and environmental education because of how internet-based technologies have diversified ways of learning, inquiring and researching about topics that intersect both disciplines. There are a variety of citizen science projects that range from the humanities, arts and science disciplines, and can be used to involve the public, including students, in research with differing degrees of democratic decision-making (Irwin, 2015; McKinley et al., 2017).

In the following subsection there is an explanation of citizen science typologies and the relative levels of agency between the experts and the participants. Considering the potential for citizen science as a mode for learning about and practicing citizenship, the remainder of this chapter provides details about the background, the value and application of citizen science to address community issues and its use in education.

2.2 Citizen Science

This portion of the chapter introduces a research approach to learn about the world and to potentially take action for it, called citizen science. Citizen science is a distinctive technique of conducting research whereby experts and non-experts work together to engage in investigating an issue of value to a community. The origins of citizen science as a concept is up for debate. Records exist showing people in Kyoto, Japan, documenting observations of the Sakura (cherry blossom) blooms from the 8th century onwards (Ramanauskaité, 2019). Reported origins of the formal use of citizen science began with studies of bird counts and migration patterns in the U.S.A in the late 1800s by untrained citizens with the help of experts (the North American Bird Phenomenology Program). Such activities were first termed citizen science in the 1990s (Riesch & Potter, 2014).

2.2.1 The Value and Contribution of Citizen Science

In modern times, the growth of information technology, the internet and the prevalence of smartphones has led to a surge of its application in the last 20 years, especially in Europe and North America (Bonney et al., 2016; Irwin, 2015). With millions of people from around the world having participated in thousands of citizen science projects (SciStarter, 2019), its increasing prominence has led to the term 'citizen science' being added to the official Oxford English Language Dictionary in June 2014 (Pulford, 2014). The Dictionary (2014) defines it as "scientific work undertaken by members of the general public often in collaboration with or under the direction of professional scientists and scientific institutions". Data from 'SciStarter', one of the largest website databases for citizen science projects, shows an almost 2000% increase in the number of citizen science projects between 2009 - 2018 (Irwin, 2018). SciStarter hosts more than 3000 projects involving millions of volunteers giving their time to support various citizen science projects (SciStarter Project Finder, 2022), while Zooniverse, a web portal dedicated to bridging the gap between projects and people, claim to have more than 200 active, paused and completed projects attracting more than a million participants (Zooniverse Projects, 2019). A measure of the success and validity of the contribution of regular citizens is the number of publications produced from this approach to research. Kullenberg and Kasperowski (2016) report a tremendous annual growth in publications with citizen science data since the early 2000s, totalling almost 2000 papers by 2015.

There is a general flow and structure to the way citizen science research is conducted. Most research begins with enquiry questions leading to some form of information collection, followed by an analysis and conclusions that help answer the original questions. Conducting fieldwork and gathering data, particularly of large populations or data points, is a time consuming process that can incur large costs and may have geographical, spatial, and/or temporal limitations. To address the growing interest in conducting research that involves the public, a guiding framework has been developed from the collective experiences of citizen science practitioners (who were part of the European Citizen Science Association working group on 'Sharing best practice and building capacity for citizen science') to establish some standards for what high quality citizen science projects look like (Robinson et al., 2018). These ten principles (see Table 2) also act as a basis for evaluating not only the project itself, but the quality and contribution of the project findings to address the community issue being researched. Advocates within the citizen science community have highlighted the potential for this innovative way to gather data at a variety of spatial scales, geographies and timeframes (Fritz et al., 2019; Wehn et al., 2021).

Ten Principles of Citizen Science
1. Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.
2. Citizen science projects have a genuine science outcome.
3. Both the professional scientists and the citizen scientists benefit from taking part.
4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process.
5. Citizen scientists receive feedback from the project.
6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.
7. Citizen science project data and metadata are made publicly available and where possible, results are published in an open-access format.
8. Citizen scientists are acknowledged in project results and publications.
9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.
10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data-sharing agreements, confidentiality, attribution and the environmental impact of any activities.

Table 2: List of the 10 principles of citizen science as published in Robinson et al. (2018).

For vital ongoing investigations, such as the monitoring of the UN SDGs, it has been recognised that relying on the traditional methods of data collection by government agencies, national statistical offices or NGOs incurs tremendous costs; for example, a national census can cost billions of dollars (Fritz et al., 2019). The costs are often high due to the large spatial coverage or density needing to be investigated, which leads to the subsequent concern with low-frequency data collection. Fraisl et al. (2020) claim how using the citizen science approach can save costs, engage the public and collect quality data for as many as one-third of the SDG's 169 specific targets.

The 17 Sustainable Development Goals that came into effect in 2015, are a set of goals that further the intentions and progress of the 8 UN Millennium Development Goals (MDGs) that began in 2000 (Sustainable Development Goals Knowledge Platform, 2020). Within these 17 SDGs are 169 targets which are monitored by branches of the UN that seek to ensure follow through by nation states towards development that respects the tripartite vision of social, economic and environmental sustainability.

Fritz et al. (2019) are making the case for citizen science to play a more active role in such important monitoring schemes that have global impacts, especially for the SDG targets that, as yet, do not have a universal methodology for measurement. Current citizen science projects support SDG 13, "Climate Action", by investigating soil moisture and rainfall with rain gauges, and SDG 14, "Life Below Water", using remote sensing and imagery to track marine debris and eutrophication impact in water bodies. The success of these projects being officially considered as data input methods for the afore-mentioned SDGs prompts Fritz et al. (2019) to suggest a framework of action to propel the use of other citizen science projects within the custodial agencies of the UN. Further investigation into the opportunities for citizen science to monitor the SDG target progress exist. Surveys of Stockholm Environment Institute (SEI) staff highlight opportunities to delve into some socio-economic targets such as sanitation and hygiene from SDG 7 using data collection platforms and mapping tools, as well as a co-created citizen science project to improve waste management in a refugee camp in the Palestinian West Bank to address SDG 12 (West & Pateman, 2017). West and Pateman (2017) offer how the citizen science method can be used to not only gather the data, but monitor and implement the SDGs, especially at a local scale. A significant advantage of citizen science over the traditional avenues for data gathering is the greater frequency and density of data collection when there are more participants actively collecting the data, as well as the reduced costs (Fritz et al., 2019; West & Pateman, 2017). As long-time citizen science advocate, Martin Brocklehurst, noted, "citizen science is like a fireworks display: it's great science, but it's short-lived" (Irwin, 2018) and he along with others are keen to see this type of experiential approach become a trusted part of natural and social science research to influence policy change (Irwin, 2018) at various levels of society. This call has been recognised by citizen science project organisers at the local city level in Hong Kong. One of the goals of many citizen science projects about biodiversity and pollution in my study are about using the data to inform stronger pro-environmental policy in Hong Kong.

To support the development of citizen science in a way that is increasingly systematic yet flexible to community needs and is based on good practice, the establishment of regional citizen science associations play an important role (Hecker et al., 2018). More established regional organisations like the Citizen Science Association and the European Citizen Science Association, and the newer entities like CitizenScience.Asia and CitSciAfrica, have formed a Citizen Science Global Partnership to support its growth and represent needs to pan-governmental organisations like the UN, policy makers and the research community (Irwin, 2018). These national or regional associations have given prominence and value to the results of citizen science projects, such as Germany's "Green paper" or North America's "eBird", both of which highlighted the impact of research results made possible by public contribution to enviro-political discussions. In their study of 24 water quality monitoring organisations, Kinchy et al. (2014) describe how the groups often have overlapping practices for conducting science, raising participant consciousness and supporting environmental policing. It is recognised that citizen science can provide what policymakers and governing institutions need to make important decisions with real-time accurate data and multi-stakeholder input. The outcomes of such interactions have, for example, led to the promise of additional funding and support to develop citizen science projects from 2017 onwards by the German Ministry of Research and Education, and the monitoring of bird species in North America (in the eBird project started by the Cornell Lab of Ornithology in 2002) enabled the American government to reassess and improve land use regulations and provide updates for the Migratory Bird Treaty (Hecker et al., 2018).

Because of the potential to involve a greater number of people in the research process to increase engagement and communication to a larger audience through citizen science, experts are more willing to create such projects to support the dual goals of enlarging their datasets and contributing to enhancing the 'public understanding of science' (Bonney et al., 2009). Citizen science could be seen to counter the traditional notion of a general lack of scientific literacy amongst the public (a deficit model) and provide opportunities for dialogue and hands-on engagement beyond top-down dissemination of scientific information (Bonney et al., 2009; Koizumi & Yamashita, 2021; Wiggins & Crowston, 2011). Leitch (2022) spoke from their 30+ years of experience as a science communicator about the shifting perspectives of scientists since the 1990s, when the public were seen as needing curated scientific information, to now where public engagement is key to challenging assumptions of power and purpose between expert and layperson. With a variety of dimensions defining the broad term 'public engagement' including engagement objectives, intended audience and types of activities, the umbrella term inherently maintains a vagueness which can limit the effectiveness of such interactions (Weingart et al., 2021). Dillon et al. (2016) noted how the most common citizen projects are driven by experts' needs for scientific research (which the authors term as the 'bald spots'), with few being the more participatory and bottom-up projects often addressing the more 'wicked problems' ('blind spots'). Another issue is the assumption that participating in citizen science projects can influence greater engagement with science, with limited empirical evidence to suggest otherwise (Martin, 2017). Though there is concern that intention has outpaced a tangible change in practice (Irwin, 2021; Leitch, 2022; Weingart et al., 2021), there is interest in greater dialogue and engagement between scientists and the public at the intersections of science, society and politics (Irwin, 2021). This interest can be seen in the growth of diverse citizen science projects, with project typology based on participant agency and engagement outcomes, which I define in the next sub-section (see Ch. 2.2.2). Following that discussion, I focus on the 'citizen' (Ch. 2.2.3), the 'science' (Ch. 2.2.4) and the use of citizen science in educational settings to consider its impact (Ch. 2.2.5).

2.2.2 Typologies of Citizen Science

To understand the history and contextualise the range of citizen science projects, it is helpful to consider the types of projects and their common characteristics. Typically there are four main attributes of citizen science projects that involve non-experts contributing to research conducted and led by an expert: (1) any non-expert can participate in the project; (2) the common methodology is consistently used by all non-experts, to ensure reliability and validity of the data; (3) the resulting data collected can be used by the expert to assist in coming up with conclusions about their study; (4) typically the wider community of experts and non-experts have access to the data, including sometimes the general public. These commonalities shown in the literature about citizen science projects lead to distinctions in approaches of various citizen science projects that consider participant agency in methodology creation, and organisational features and aims of the projects (Rushton & Parker, 2019). The discipline of citizen science has grown in variety as well as purpose, allowing a spectrum to develop between projects that are entirely controlled and developed by the experts to those that are co-created by the non-experts and experts together. This range is distinguished by aspects of involvement of the non-experts, and in educational contexts, would be known as the degree of participant agency: contributory, collaborative and co-created (Bonney et al., 2009); as expressed in a spectrum diagram illustrated in Figure 1.

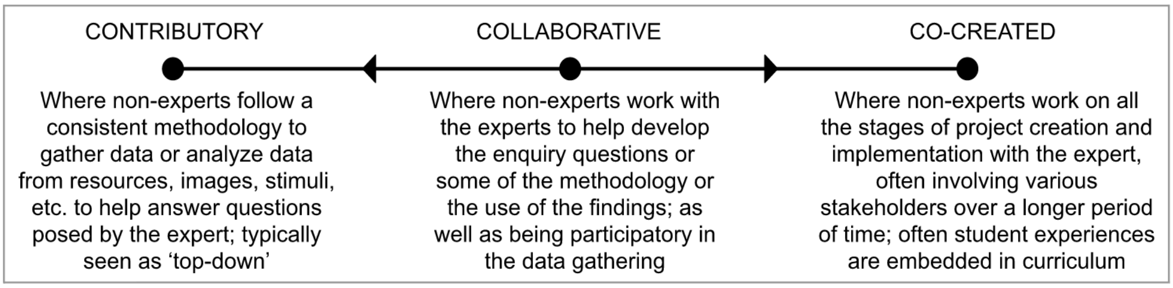


Figure 1: A spectrum of 3 types of citizen science projects ranging in the level of involvement in the project design by the non-experts.

These categories are further described when considering the kind of work that is being carried out by the non-experts in the following four ways, as suggested by Bonney et al. (2016): (1) "data collection": volunteers gather data and information, (2) "data analysis": volunteers are part of the interpretation of data and information (3) "curriculum based": pedagogically-applied and youth-focused approach to answer student-generated questions, and (4) "community science": often a co-created investigation initiated by the public to solve local questions. A typology by Haklay (2013) that also considers the manner of participant engagement can be separated into the following groups: (1) "crowdsourcing" - participants act as 'sensors' to gather data and information, "distributed intelligence" - participants offer their analytical skills to solve questions, "participatory science" - participants help to define the problem as well as gather data, and "extreme science" - participants participate in all stages of the research from problem definition, data gathering and analysis. An additional way of grouping citizen science projects considers the inherent nature and the objectives of the projects and the advancement in technology use for citizen science projects, as developed by Wiggins and Crowston (2011):

- Investigation: projects that aim to obtain large datasets from a real physical environment
- Virtual: projects that aim to obtain large datasets from internet-based communications technology
- Education: projects with aims to enhance student experiences in formal and informal settings
- Action: projects at grassroots levels to engage the local community in issues of concern
- Conservation: projects at grassroots levels that include stewardship and education as part of its impact

The following table compares these recent typologies of citizen science linking traits of participant agency with the objectives of the citizen science projects, to highlight similarities and differences between nomenclature (see Figure 2). The placement of the various terms along the spectrum shown in Figure 1 is determined by their descriptions as originally defined by the authors stated in the 'author' column.

Author	**← Contributory ↔**	**Collaborative**	**↔ Co-created →**
Haklay (2012)	Crowdsourcing Distributed intelligence	Participatory Science	Extreme Science
Wiggins & Crowston (2011)	Investigation Virtual	Education Action Conservation	
Bonney et al., (2016)	Data Collection Data Analysis	Community Science	Curriculum-based *

Figure 2: Recent typologies of citizen science organised along a spectrum categorised by participant agency.

Older descriptions of typologies of citizen science or public participation in scientific research (PPSR) from 2004-2008 can be found in Table 3 in Shirk et al. (2012) that also show relative comparisons to, and fall neatly along, the 3-part 'contributory-collaborative-co-created spectrum' as shown in Figure 1.

2.2.3 The 'Citizen' in Citizen Science

Citizen science should be accessible to all (Bonney et al., 2009; Herodotou et al., 2022; Makuch & Aczel, 2020; Sorensen et al., 2019). This potential has been commonly lauded, however studies reveal the vast majority of participants skew towards being well-educated, from white ethnic groups, of a comfortable socio-economic level, employed and middle-aged or older, as summarised by Pateman et al. (2021). In addition, there is a debate, especially in the Global North, about the world 'citizen' in citizen science because of its meaning to different groups of people (Eitzel et al., 2017; Cooper et al., 2021). It can be viewed from a socio-political angle of nationality, where questions about one's citizenship can bring about a sense of exclusion. The title used to describe participants can be suitable in one context, but perhaps not in other cultures or languages. A lack of participation by certain groups may even create gaps or biases in the data (Sorensen et al., 2019). These kinds of complexities add to the real concern about making citizen science more inclusive.

Of particular consideration are Robinson et al.'s (2018) 'Ten Principles of Citizen Science', which describe ideals around the value and use of citizen science for scientific endeavours (see Table 2). While providing shape to an approach that has some definitional fluidity, there are specific principles that are somewhat problematic when considering who is likely receiving the benefits to engage in such practice, and who is not. A key criticism is how there can be a disconnect between the investigated topic being of interest to scientists and researchers, but not to local communities because it may not address their more pressing needs (Pandya, 2012). As Calabrese Barton (2012) asks, "whose science is this?" (p.2). A perceived barrier to participate, one that could further exacerbate the impression of a disconnect, may link to a lack of clarity about how participation influences positive change on the issue being investigated (Shinbrot et al., 2021; Mintz et al., 2022). Principle #3 offers that both parties should benefit from taking part, however, with most projects being of a contributory nature, the value of participating often touches upon intrinsic elements like feeling good about one's effort towards a project that could positively impact policy (Geoghegan et al., 2016). Principles #5 and #7 highlight the importance of participants receiving feedback and acknowledgement, and studies suggest this boosts motivation to participate (West & Pateman, 2016;). However, the quality of such communication can vary, and the likelihood of citizen science projects being published skews towards data collected by the more educated and wealthier demographic groups with time to volunteer (Calabrese Barton, 2012; Burgess et al., 2017). This skew pulls focus on the structural limitations of marginalised communities with socio-economic and mechanistic barriers to participate and gain, both intrinsically and extrinsically (Calabrese Barton, 2012; Pandya, 2012; Shinbrot et al., 2021).

Some proposed steps to improve upon the criticisms above include planning strategically and mindfully around issues of accessibility and diversity, and involving the perspectives of many stakeholders, especially established local community organisations, through the project development, execution and dissemination phases (Brouwer & Hessels, 2019; Cooper et al., 2021; Pandya, 2012; Pateman et al., 2021; Sorensen et al., 2019; West & Pateman, 2016). Additionally, a reframing of the purpose of citizen science could pull more explicitly from the rooted sense of place which participants have, when supporting scientists with their research (Calabrese Barton, 2012). This idea can extend to how to engage students using a citizen science approach for science literacy and building agency, a topic I discuss further (see Ch. 2.2.5 and Ch. 3.3).

Another aspect gaining attention in the literature is about what motivates or discourages people from participating in citizen science projects. Various studies about motivations have highlighted that learning and gaining knowledge, having an interest in contributing to scientific research are some common drivers to participate (Merenlender et all, 2016; Shinbrot et al., 2021; West & Pateman, 2016). Some barriers are personal, like the perception of a lack of knowledge, lacking the time to participate and (Merenlender et al., 2016), while other constraints are more structural about the project itself, such as the uncertainty about participation value, the complexity of the methodology and lacking awareness of participation opportunities (Hobbs, 2012; Shinbrot et al., 2021; van de Velde et al., 2017). While addressing these barriers to host training sessions, manage data quality protocols and create simple yet meaningful methods for data collection takes more time for the experts to carry out, the outcomes are generally positive for the research purposes and support greater citizen scientist engagement (Dickinson et al., 2012; Froeling et al., 2021; van de Velde et al., 2017; Volten et al., 2018; West & Pateman, 2016).

Those who do volunteer their time offer much-needed support to organisations running projects within particular constraints. From a practical and financial point of view, using volunteers as citizen scientists to support research has allowed for organisations, such as the Appalachian Trail Conservancy in the U.S.A., to save more than US$30,000 per year in wages for field technicians to gather ecological health and biodiversity data (Cohn, 2008). The logistics of seasonally hiring experts for a 3 to 4-week period during the summers to conduct the measurements is not easy, and the engagement required from citizen scientists is only a 24-hour period every June which means that a large volume of volunteers (up to 41,000) are attracted to the relatively short time commitment and effort. While this is seen as a great benefit for organisations with limited financial resources, there are negative impacts in the potential loss of short-terms employment and in the sentiment that participants are seen as ‘free labour’ (Eitzel et al., 2017). Gardiner et al. (2012) also acknowledge the value of the citizen science movement from a financial perspective, sharing that citizen science results verified by experts cost only 32% of the cost of expert-only collected data (based on a comparison of 3 lady beetle/ladybird projects in the U.S.A. and the U.K.). This suggests best-practice approaches for future citizen science projects to combine the accuracy of data collected by scientists and the volume of data collected by many citizen scientists. Additionally, other positive benefits include conservation impacts that support species biodiversity, for example, the results of data collection and analysis of the project organised by the Appalachian Trail Conservancy led to the discovery of the decline of a particular bird species which informed pro-environmental future policies and permits for development (Cohn, 2008). It is recognised that biodiversity conservation projects with aims to quantify population changes need to also have management plans that enforce pro-environmental action at pre-established trigger points (e.g. a significant drop in species population), otherwise such monitoring initiatives aren't fulfilling their key objectives (Lindenmayer et al., 2013). In a similar environmental policing vein, volunteers of water monitoring organisations in Pennsylvania, U.S.A., highlight aims of their data gathering to include collecting evidence for potential litigation against polluting industries, as if they were an extension of environmental protection agencies (Kinchy et al., 2014).

There is no doubt that the involvement of citizen scientists offer many advantages like increased data collection coverage spatially and temporarily, but scepticism exists about the quality of the data collected by non-experts (Burgess et al., 2017). Some studies come to the defence of citizen science project participants, saying that if the methodology for environmental monitoring or biodiversity observation is clear enough, and participants are provided adequate training, their contributions have high levels of agreement with data collected by expert researchers (Crall et al., 2010; van der Velde et al., 2017). However, there are studies that show some variability amongst citizen scientists (project participants) in terms of the density and precision of data collection (Genet & Sargent, 2003; van der Velde et al., 2017). These studies showed that variation was found amongst youth and adult participants alike (on separate projects). In a particular project observing calling amphibians, having a background in or prior experience did not influence one's accuracy in identifications, meaning that even the more knowledgeable participants were inaccurate some of the time (Genet & Sargent, 2003). To minimise such effects, Tregidgo et al. (2013) recommend the use of verification studies by experts to compare the data quality of citizen scientists. In their experience, they reported how citizen scientists were more accurate when the signature of the data being observed was large (lichen presence and abundance compared to roadside NOx exposure). This suggests how the compromise between simplifying the methodology enough for non-experts while maintaining some research rigor can still produce meaningful results (Tregidgo et al., 2013).

2.2.4 The 'Science' in Citizen Science

The word 'science' in citizen science may be interpreted as 'matters within the discipline of science', though what it highlights can be directed more towards a scientific enquiry approach. There has been much discourse about the validity of the traditional system of the hypothesis-driven scientific method in this modern age, which emphasises objectivity and inductive reasoning based on experimental results. Nowadays, the availability and collections of large datasets, the computational power for extracting meaning out of that data that separates the preconceived notions of the investigator with the investigation results, and using models to trigger questions highlight enhancements to the ways in which people can inquire in a scientific way (Irwin, 2015; Voit, 2019; Windschitl et al., 2017).

Regardless of the range of approaches, they are all generally part of a scientific scaffold that includes the creation of enquiry questions, conducting some research and considering conclusions based on the analysed data. As such, citizen science follows a similar architecture and has tremendous flexibility built in, depending on the projects' aims and objectives (Fraisl et al., 2022).

Organisations such as the UKRI, United Kingdom Research and Innovation organisation, and the NSF, National Science Foundation in the U.S.A, that have funded traditional scientific investigations are also financially supporting research using citizen science approaches (Bonney et al., 2009). Citizen science projects range from topics related environmental issues such as light pollution monitoring ("Globe at Night"), to ecological biodiversity ('iNaturalist'), to genetic sequencing ("Phylo") to more social questions such as archaeological discoveries ("Global Xplorer") and monitoring of the UN Sustainable Development Goals (SDGs) using projects like "Narrative Atlas", to name a few that include, but also go beyond the realm of science (SciStarter, 2022; Zooniverse, 2022).

For citizen science implementation, there is a growing trend in environmental literacy, science capital and crowdsourcing solutions for socio-environmental challenges, because they yield positive results from community involvement at the global scale and engage participants with an altruistic sense of contribution (Baruch et al., 2016; McKinley et al., 2017). Using 'Tomnod', a spatial mapping project to identify points of interest, as an example, in its 9 years of active service (the project became inactive as of August 2019), millions of citizen scientists provided support to a variety of legitimate investigations, as described in the following examples (Maxar Technologies, 2019). By accessing real-time public aerial images, 'Tomnod' participants helped first humanitarian response teams during natural hazard events like the 2015 earthquake in Nepal by identifying buildings and areas that were damaged. Another investigation that benefitted from a greater volume of data in a shorter period of time was the Antarctic Weddell seal population study, where 5000 'Tomnod' citizen scientists analysed the same spatial area in two months as academic scientists covered in 10 years (Maxar Technologies, 2019).

Much has been positively written about the value and impact that citizen science contributions have had (Cohn, 2008), especially in the field of conservation and environmental monitoring (Gardiner et al., 2012; Lindenmayer et al., 2013; Kinchy et al., 2014; Volten et al., 2018). Such research projects often revolve around measuring water, soil or air quality, or making observations about changes in ecological biodiversity. The contribution of participants in citizen science or other participatory approaches have brought value by, for example, creating small networks of sensors to become part of wider monitoring systems (Volten et al., 2018), helping to reduce costs of conducting monitoring research (Gardiner et al., 2012), and increasing community conservation action (Merenlender et al., 2016). To support the development of quality citizen science projects that engage the public in such research, Fraisl et al., (2022) published a primer on the guidelines to develop and implement such projects for the good of the natural environment and the participatory research field.

While concerns about data quality and reliability exist (see earlier discussion in Ch. 2.2.), the benefits outweigh the constraints thanks in part to more consciously-designed projects with quality controls and training for participants (Gardiner et al., 2012; Tregidgo et al., 2013). Additionally, it is not only the environment that gains, as I've discussed in the previous sub-section about the 'citizen' (see Ch. 2.2.3). Various studies have also shown impacts on participants of citizen science projects ranging from improving topic knowledge and building connections to place, to building leadership skills and enhancing one's self-efficacy to address environmental issues (summarised in Appendix A in Volten et al., 2018; van Noordwijk et al., 2021). The following subsection discusses how these kinds of impacts are seen amongst youth who participate in citizen science projects as part of their formal and informal education.

2.2.5 Citizen Science in Education

With increasing access to easy-to-use technology connecting the expert with the non-specialist participant, citizen science as an approach has been increasingly used as part of science and experiential environmental education in schools (Schuttler et al., 2017; Kermish-Allen et al., 2019). While there are acknowledged limitations about benefits to marginalized communities related to the components of citizen science from a critical studies perspective (Calabrese Barton, 2012; Cooper et al., 2021), citizen science could provide the opportunity to contextualise research for local communities that relate to their lived experiences, and this demonstrates how flexible this investigative approach is at scale and can be applied in an educational setting (Ballard et al., 2016; Kermish-Allen et al., 2019).

Although citizen science is a practice that has been used at various scales for many decades, published evidence of its incorporation within primary and secondary educational institutions is not as extensive. As such, it is important to consider how effective citizen science can be in learning about the concepts and issues around the citizen science project, as well as the impact that the experience has on the participants. Connecting to the tenets of constructivist learning theory described earlier (see Ch. 2.2.1), environmental citizen science projects would likely involve students building on their knowledge through observations, critical thinking and peer discussions. This process of learning seems to have a more positive influence on environmental education achievements than in contexts where knowledge is simply provided to students (Arik and Yilmaz, 2020). Schools and environmental education centres have started to incorporate citizen science, and more recently, co-created citizen science, as part of their teaching and learning initiatives (Ballard et al., 2017, 2019; Tsueng et al., 2019; Roche et al., 2020; Herodotou et al., 2022). As the name suggests, co-created citizen science happens when the expert and non-expert are equally involved in designing and executing the project framework and methodology, as well as gathering the data, analysing it for findings, and ultimately dissemination of the data (see typologies in Ch. 2.2.2). Citizen science as a pedagogical approach differs from other types of student-led inquiry, project-based learning and SSIBL approaches due to the data being used by those outside of the educational institution (i.e. the experts/scientists). My interest in citizen science as a tool for teaching and learning is linked to this idea that the output of student citizen science involvement is to also support scientists in their research, thereby giving enhanced meaning and value of the students' contributions. Co-created citizen science demands greater engagement between both parties, and studies have suggested the greater involvement could lead to enhanced knowledge, scientific literacy, capacity-building and conservation outcomes (Bonney et al., 2009; Ballard et al., 2018; Kermish-Allen et al., 2019). With limited empirical evidence to suggest these potential effects are a result of more a participatory approach to research (Gunnell, 2021), my quasi-experimental mixed methods study comparing the impacts of contributory and co-created citizen science projects on students offers much needed insight in this regard.

Learning to do science is more powerful than learning about science as there is a legitimate concern that relevance to students' lives is a key driver in interest and continuation of learning within the sciences (Calabrese Barton & Tan, 2010; Edwards et al., 2018). Developing the "activist mentality", where one reflects on the status quo and ways to challenge it, (Bencze & Alsop, 2014) using various educational approaches may help put the use of citizen science and co-created citizen science into a greater context for sustainability education. Research suggests that personalised enquiry or democratic participation improves engagement levels of all participants (DeCaro & Stokes, 2008; Hecker et al., 2018), which is also represented in Harris and Ballard's (2018) framework supporting environmental science agency in students. This opens an enquiry into the effectiveness of co-created citizen science in participant engagement and subsequent action. Though not specifically about co-created citizen science but rather about a co-created learning experience, student teachers undergoing training for environmental education reported increased pro-environmental action and shifts in their mindsets when they were made part of the analytical process of program evaluation (Nielsen et. al., 2012). Although altruism and 'doing good' are cited as motivating factors in taking further action in citizen science initiatives, there is evidence that without valued feedback and an easy user experience, the likelihood of engagement and involvement diminishes (Baruch et al., 2016). Strategies such as incentives or making access and the experience easier, help to kick-start behavioural changes (Monroe et al., 2017), though there are no published studies at present considering this consequence of citizen science in Hong Kong, to support this wider claim.

The citizen science projects used as part of science or environmental education programs in schools show a range of effects on students. Qualitative interviews with 54 American secondary school students participating in ecological citizen science projects revealed enhanced sense of self-efficacy, greater topic-specific knowledge and the interest to engage in conservation behaviour (Ballard et al., 2017). Though it was not the case with every participant, evidence of environmental science agency was observed by the researchers, prompting implications in project implementation to improve youth engagement. A study with 45 Norwegian secondary school students involved in an air-quality citizen science project measuring change through pre- and post-surveys found that while content knowledge about air pollution improved, pro-environmental worldviews declined somewhat (Grossberndt et al., 2021). The researchers found that the interpretations of the New Environmental Paradigms scale used to understand student environmental values was challenging and may have contributed to the different results between the surveys. The impact on behaviour was small, with about 25% of the students taking action about air-quality issues. While showing varied gains for students who engage in citizen science projects, both studies had small samples of students and used predominantly either qualitative or quantitative methodologies to evaluate the impact of their respective projects. There is a need for studies to include both qualitative and quantitative ways to understand what is happening and why. Furthermore, the behaviours reported in these studies focused primarily on those that were related to the project topic and wider pro-environmental actions were not reported. Citizen science volunteers in nature-based or environmental projects, by nature, are often self-selecting and therefore often already demonstrate pro-environmental attitudes, and some studies show positive attitudinal impacts on youth where projects are embedded into their school curricular experiences (Ballard et al, 2017; Bonney et al., 2016; Chase & Levine, 2018). Other studies have shown mixed results about shifts in environmental values and the longevity of impacts on student learning (Aivelo & Huovelin, 2020; Hsing et al. 2020), so my study addresses these research gaps investigating the impact of citizen science experiences on a larger sample of students and using a mixed methods approach.

While there are no published studies of the impact of citizen science experiences as part of an environmental education programme delivered in Hong Kong schools, studies by researchers like Ballard et al. (2017) and Hsing et al. (2020) suggest how environmental education using citizen science can have positive impacts on knowledge, environmental values and interest in taking pro-environmental action. Their studies included multi-day projects that required longer time commitments from the teachers and students involved, and experiential education learning theories suggest that such deeper engagement over time intensifies the cognitive learning impacts (Dewey, 1925; Dirkx et al., 2006; Chawla & Cushing, 2012). However, even one-off experiential environmental education programmes in Germany, Taiwan and Hong Kong have been shown to positively influence greater topical knowledge generation, pro-environmental values and student engagement (Sellman & Bogner, 2013; Ma, 2016; Pan and Hsu, 2020). While these studies were not measuring citizen science projects as part of their environmental education programmes, such positive attitudinal and learning impacts raise the question about what the effects of one-off, as well as more longer-term, environmental citizen science projects are, given that such projects are often experiential and require students to be engaging within nature.

2.3 Chapter Summary

In this chapter I demonstrated the links between experiential, environmental and global citizenship education by referencing the influential works of scholars like Dewey, Mezirow, Freire and hooks. Integrating the principles of the constructivism learning theory, I explained the potential of these different literatures to complement each other. Delving into the critical lenses within education for change highlighted opportunities for more participatory and experiential learning engagements like citizen science, though this approach has its own limitations related to who the beneficiaries are and how. After outlining what citizen science data and experiences have provided the social and scientific worlds, I explored some of the ways that citizen science is used as a pedagogical tool in the formal and informal school settings. Key studies have shown there are impacts on citizen scientists in terms of knowledge about the researched topic, their capacity-building and self-efficacy, and conservation behaviour. This overall examination of the intersecting literature between experiential, environmental and citizenship education and citizen science reveals some research gaps. There is a lack of conclusive findings about how citizen science influences pro-environmental knowledge, attitude and behaviour in school settings, using qualitative and quantitative methods. I want to focus on understanding the impact of environmental citizen science experiences on pro-environmental values, attitudes and behaviours of students. This investigation is centred around the experiences of teachers, students and citizen science organisers in Hong Kong, where my personal background and professional experience is situated. This study to measure environmental citizen science impact using quantitative and qualitative methodologies, is the first of its in Hong Kong, and likely Asia.

CHAPTER 3

3 Educating for Change: Shrinking the Value-Action Gap

This chapter introduces the phenomenon of the 'value-action gap' and the approaches used to address it. From using methods inspired by marketing to theories in behavioural psychology, the mission to shrink the distance between what people care about and what actions they take, has been a complex one to achieve. An exploration of the various models from behavioural psychology, especially environmental behaviour psychology, gives insight about the variables that influence behaviour. A deep dive into the frameworks to evaluate one's values, attitudes and behaviours reveals influential models like Ajzen and Fishbein's (1980) Theory of Planned Behaviour, Stern et al.'s (1999) Value-Belief-Norm Theory, and Barr and Gilg's (2007) 'Environmental Behaviour Framework'. I analyse a variety of environmental values scales from the Dunlap and Van Liere's (2008) 'New Ecological Paradigm' scale, Nisbet et al.'s (2009) 'Nature Relatedness' scale and Bogner and Wiseman's (1999, 2006) 2-MEV scale to determine the most appropriate options for my research context in Hong Kong. I then bring the focus towards the context of school, and how environmental education has played a role in encouraging youth to engage in more pro-environmental behaviour. Similarly, I examine what the impact of citizen science in educational settings has been to change how youth feel, think and act towards the natural environment. As it becomes clearer where the gaps are in the literature about a holistic understanding and empirical evidence of citizen science's potential to influence value-action gap changes, I draw attention to the Hong Kong context, my geographic area of experience and interest. Synthesising what is known about citizen science and environmental education in the city, I identify opportunities where my research helps to fill vital gaps in understanding how an experiential environmental education approach like citizen science can impact the pro-environmental values, attitudes and behaviours in Hong Kong students.

3.1 Background about the 'value-action gap'

The 'value-action gap' is a concept that is being increasingly discussed in spheres like socio-behavioural psychology, sustainability marketing and green government policies, and stated simply, is the difference between how people would like to act based on their values, and what they actually do (Barr, 2006). While the value-action gap is of interest to many sectors of society, the marketing and consumer industry has especially driven much investigation in understanding how people turn their intention to behave in a certain way into action as consumers (Foxall, 2001). As such, the moral question becomes a matter of directing one's values and actions towards those that bring about more good than harm, which is the position of sustainable development and the basis of the UN Sustainable

Development Goals. To clarify, I use the term 'environmental values' to mean a set of closely related attitudes about nature and natural resources, as described by Bogner and Wiseman (1999, 2006) to be the higher order factors than general attitudes. This position stems from conceptual work by Rokeach (1971) where he explains that values are the foundations of attitudes, and they can ultimately influence behaviour. Environmental values, therefore, are the core building blocks of desired state of being or behaviour which determine the many attitudes people have towards environmental issues and circumstances.

The impetus for understanding the key drivers that influence how people move from having values and attitudes about a certain issue to taking some form of action is a growing field given the current state of wicked problems like socio-economic inequality and climate change (Young & Pelenur, 2022). There are many social, financial and political dimensions to encouraging people to act or change their behaviours (Tavri, 2021). Some of the most common strategies are using financial incentives, like returning plastic bottles in exchange for small amounts of money, or financial disincentives or penalties, for example, the plastic-bag levy to discourage people from asking for one and encourage them to bring their own reusable bag. These respective 'carrot and stick' approaches have met with some success, though they are often not used only in isolation. For example, the plastic bag levy in many cities across the world has led to significant increase in customers carrying their own, usually more reusable, bags when shopping, with a U.K. study showing a 97% decrease in the number of plastic bags used per shopper (Park, 2022). However, these kinds of campaigns are often accompanied by additional factors that influence more people to engage in such behaviours, such as with incentives, nudges and social marketing (Monroe, 2003, Reddy et al., 2017). Because humans are social beings, the influence of what others do has a pronounced effect on an individual, and the more visible the action, the more likely others will also demonstrate it (Babutsidze & Chai, 2018). An Australian study of adults taking pro-environmental action showed how there was greater propensity for the more visible green actions like recycling and using public transport, especially if their neighbours were also demonstrating such behaviours (Babutsidze & Chai, 2018).

Though some see economic development and environmental health to be mutually exclusive goals as exemplified by the centuries-old linearity of the "take-make-dispose" system, a burgeoning movement around the idea of circular economies proposes a framework that allows for the triumvirate pillars of sustainability (social, environmental and economic) to coexist and scaffold each other by (Kneese, 1988; Raworth, 2017). In their report entitled "Towards a Circular Economy", the Ellen MacArthur Foundation, an organisation set on accelerating socio-economic systems towards more sustainable living, envisions a world where "today's goods are tomorrow's resources" (Ellen MacArthur Foundation, 2013). The philosophies that underpin these ideas about more environmentally sustainable lifestyles are of great value to the NGOs, the consumer industries and governments, alike, as they employ various techniques to encourage a shift in human behaviour (Raworth, 2017). Businesses and organisations have been creating incentives towards a more environmentally-conscientious lifestyle by developing standards to raise awareness and green labelling for consumption of goods and services. The 'Marine Stewardship Council', the 'Fairtrade' certification marks and the 14000 series of the ISO standards are some of the more common international examples of green labels and standards that aid the consumer in making ethical consumption decisions (Fairtrade International, 2020; ISO, 2019; Marine Stewardship Council, 2020). The presumption is that consumers will use these labels to make purchasing decisions.

Though one may think that having more knowledge alone may not be enough to spur a behavioural shift, as it also depends on the quality of information. Personalised data about one's energy consumption compared to a population's average has been shown to trigger a shift in energy use because it links to the innate trait of humans to compare ourselves to those around us (Cabinet Office Behaviour Insights Team, 2011). Yet interviews with 81 self-declared green consumers in the U.K. revealed a more complex suite of factors including past consumptive behaviour, cost and product availability, product quality and production, time for corporate product research and even guilt (Young et al., 2010). In contrast, Lin and Huang (2012) conducted a survey posing an incentivised questionnaire to mostly adults attending green fairs and activities in Taiwan and found that green product price and quality wasn't as important as perceived psychological benefits and novelty-seeking when making purchasing decisions. Since some studies engage with respondents already more inclined to label themselves as 'green' consumers, these kinds of findings require further research with populations who may not see themselves that way (Young et al., 2010; Lin & Huang, 2012). As more knowledge does not necessarily lead to greater action, I introduce other variables from the behavioural psychology literature that could influence behaviour below and in the following subsection.

There is much debate about the most influential factors on behaviour. However, it is increasingly acknowledged that purely financial offers to shift behaviour, despite their successes in urban road-pricing and a plastic bag levy (Dobson, 2007), are not ideal, and a movement to instil ethical citizenship is more long-lasting (Dobson, 2007; Young et al., 2010). Considering an educational setting, certain solutions would be more appropriate than others. For example, using a financial prize may send the wrong message and limit the opportunities to develop intrinsic motivations for behavioural change. Such monetary incentives would also be unsustainable for formal and informal educational institutions. Thus, it is the idea of citizenship which rooted in deeper aspects of one's values, attitudes and intentions that should inspire change, aspects that will be discussed further in this chapter.

There are various explanations for the existence of 'value-action gaps'. The scale of socio-economic, political or environmental challenges can be intimidating, as university students shared during semi-structured interviews that their contributions like recycling or turning lights off, despite them being well-intentioned, may not create much impact (Chaplin & Wyton, 2014). A sense of helplessness or feelings suggesting that these issues and their solutions are outside of one's 'region of control' or are the responsibility of agents more powerful than them (like corporations and governments) creates a hesitation to act (Kollmuss & Agyeman, 2002; Chaplin & Wyton, 2014; Hickman et al., 2021). Kollmuss and Agyeman (2002) discuss that sometimes the barriers for engaging in environmentally-positive behaviour are too high, and that there may be variances depending on socio-economic status. Monroe (2003) describes the keys for effective campaigning to influence behavioural change lie in catering the message to the audience, knowing the right kind of information to disseminate and to create ways to build commitment. Evidence from household interviews of green behaviour in eastern Canada about backyard composting and water efficiency highlighted challenges with program design and unaddressed barriers for action, leading Mckenzie-Mohr (2000) to develop a "community-based social marketing" approach that brings these issues to the forefront. Barriers included not having enough information to carry out the pro-environmental behaviour (composting), feeling that carrying out the behaviour would be inconvenient, and feeling hesitant about involving others in their actions. These types of barriers are similar to the personal constraints revealed in studies about motivations and barriers to participate in citizen science projects (see Ch. 2.2.3). While it is understandable that time and financial limitations may negatively impact the scope of a behavioural change campaign, it is, nonetheless, important for the campaign's success.

Another reason for the 'value-action gap' is more related to the complex variables that go into decision-making, as shown by focus-group interviews with adults (Barr et al., 2011). Their conversations revealed an interesting dissonance between green consumerism and the suggestion that people should consume less to address environmental sustainability issues, which adds to the moral challenge of determining the most appropriate pro-environmental behaviour. Schultz (2000) argues that it coalesces around the idea that increasing distance from nature and greater urbanization has led to a diminishing connection with the natural environment, leading to an 'out of sight, out of mind' phenomena in the public. This growing disconnect and the lack of acknowledgement of one's impacts on other living things on Earth is also linked with less visible biodiversity. Impressions of randomly selected fifth graders in a Houston city school in the U.S.A., who were asked to describe and draw nature, echoed Schultz's concern: "Nature, it's out there where the lions be. It is out in the open" (Chawla & Derr, 2012, p.6). Only 18% of those students drew personal interactions of themselves in nature and confessed that they didn't see nature as a personal experience because they were taught that "nature is not the city" (Chawla & Derr, 2012, p.6). This growing field of research about environmental attitudes and well-being suggests that humans do have a natural tendency to look for a connection with nature and other living beings. I return to this idea about links with nature when discussing the variety of scales to measure environmental values in the next subsection.

3.2 Behavioural Psychology Theories and Environmental Behaviour Frameworks

This subsection considers a variety of theories and frameworks from the behavioural sciences, and especially those dealing with understanding environmental behaviour psychology. My exploration through the literature introduces frameworks that have led to many studies testing their effectiveness at predicting pro-environmental action, and I justify the use of Barr and Gilg's (2007) Environmental Behaviour Framework and Bogner and Wiseman's (1999, 2006) 2-MEV scale to address my research questions and context. An excerpt of the table used to synthesise the various frameworks and scales can be found in Appendix A.

As discussed by Mckenzie-Mohr (2000) and Barr (2006), the research surrounding behavioural change in the context of environmental sustainability has brought the fields of psychology, geography and marketing together to reveal that environmental values, situational and psychological variables interact to address the value-action gap. They suggest that closing the value-action gap requires more than 'one-way dissemination' policies and top-down approaches, but rather comprise initiatives valuing societal input and the development of behavioural intent, to name a few. Randomly selected household interviews (n = 2221) conducted in southern England by Barr (2006) and Barr and Gilg (2007) found how social, environmental, psychological and situational variables, such as environmental values, personal experiences, self-efficacy and knowledge, have an influence on behavioural intention, which may subsequently lead to pro-environmental action.

For their research, Barr and Gilg (2007) used the "Theory of Reasoned Action" and the "Theory of Planned Behaviour" (TPB) from social psychology (Ajzen, 1985; Ajzen & Fishbein, 1980) to develop ideas that adding 'behavioural intention' as a variable could better predict 'actual behaviour'. These theories posit that behaviour is based on two important elements: (1) the attitudes one has towards the desired behaviour, and (2) the social norms and influence of those social expectations to one's sense of intention. As Ajzen and Fishbein (1980) proposed a formula for this theory, many researchers have tried to empirically test the assumptions about behavioural intentions and have found mostly positive results from intervention studies across disciplines and meta-analyses reviews (Ajzen, 2012; and see summary described by Kollmuss & Agyeman, 2002). The relationship between one's intentions and behaviour is complex due to factors beyond 'reasoned action' and a person's capacity for rational thinking (Ajzen, 2012). Furthermore, Ajzen and Fishbein's TPB considers the impact of the following 3 elements: (i) one's attitude about actions that will lead to a positive outcome, (ii) the perception of the social pressure and how much importance one gives to the opinion of people deemed influential in their lives, and (iii) one's perception of their own ability and any personal control they have for modifying their behaviour. The third element spotlights the concept of 'locus of control' that is further elaborated by Bandura (1997) and Wigfield and Eccles (2002) in their concepts of 'self-efficacy' and ‘expectancy-value model of achievement’. These constructs and models include variables that would be appropriate to consider when wanting to measure impacts of an environmental education experience on youth, such as I have done in my study with environmental citizen science projects.

Bandura’s (1997) concept distinguishes between two expectancies: (1) self-efficacy: the belief that one has the skills required to successfully carry out a particular behaviour that will lead to a particular outcome, and (2) outcome: the belief that a particular behaviour will lead to a particular outcome. These are components that help to develop one’s agency to take action and can be considered to influence individual and collective environmental behaviours or action (Koskela and Paloniemi, 2022). Agency is about the capacity of a person to consider what actions to take and how (Bandura, 2006), and could be considered as one of the main prerequisite psychological traits which become active before one performs an intentional behaviour. Perceived self-efficacy plays a role in determining how long someone will persist with a given behaviour; the more their self-belief, the longer they will stick with it. A study surveying 1,300 Californian and New York 3rd - 9th grade students about their sense of control revealed that the younger students would lose motivation to continue an action if they felt they didn’t know the factors behind what creates success versus failure, and if they felt that those factors were beyond their control (Connell, 1985). In Connell’s scale, there was validity and internal consistency between variables, which allows for generalizability in educational psychology, though there was less of an impact for junior high-school students; perhaps due to the influence of the questionnaire language and questions being the same across seven grade levels. A similar issue of cognitive understanding and relevance based on age was addressed by the creation of a separate scale to measure environmental attitudes (the NEP scale) of pre-adolescents instead of youth and adults (Dunlap & Van Liere, 1978; Jackson et al., 2016; Jackson & Pang, 2017; Manoli et al., 2007).

Considering the overlap between behavioural theories and environmentalism, Monroe (2003) suggests the connections between the ‘Environmental Citizenship Behaviour’ framework by Hungerford and Volk (1990) and the ‘value-belief-norm theory of environmentalism’ by Stern (2000) share common traits of a sensitivity to the environment, knowledge, environmental literacy and the belief in the skills to tackle the environmental issue. Following this line of thinking, having such beliefs would lead to a greater development of one’s moral code and norms when it comes to environmental issues, and these could spark a sense of responsibility or obligation to act. Environmental literacy is distinguished from other types of literacy in that it has a strong element of action that stems from having the knowledge, attitudes and skills that are environmentally appropriate, as defined by Disinger and Roth (1992). The ‘norm-activation’ model research by Schwartz (1977) suggests that the influence on behaviour is greater when people are conscious of the negative impact humans have on the environment and have a belief that they have a duty to respond. This creates an opportunity for pro-environmental organisations to develop more effective educational and awareness campaigns to add positive pressure to one’s sense of duty, rather than simply focus on the communication of which behaviours should be promoted, such as with social marketing as previously mentioned. With a reasoned focus on supporting the educational side to develop one's knowledge and literacy, Monroe (2003) suggests that this is a realm well-suited to adults who have a strong sense of self, are quite self-directed as learners, and are motivated to solve problems. For 13 years I have worked in schools teaching world issues and engaging students, from kindergarten to graduation, in environmental educational experiences. Educational research has highlighted the kinds of impactful learning conditions that motivate youth to learn about issues that matters to them (Aslan & Reigeluth, 2016; Bennett et al, 2018; Cukurbasi & Kiyici, 2018; Geraci et al., 2017), and I would argue that experiential environmental education approaches such as citizen science could be just as influential and powerful in youth as in adults.

Behavioural intention is linked with one's actual behaviour, therefore barriers to encouraging intent also need to be lowered to prompt actual action (Chawla & Derr, 2012; Ballard et al., 2017). Demographic factors like years of education and gender seem to play a role in engaging with environmental issues, with females reportedly being less knowledgeable about environmental issues, though more emotionally invested (Kollmuss & Agyeman, 2002; Xiao & Hong, 2012, 2017), though there is a concern that these differences may be a result of a less robust statistical test, rather than gendered differences in reality (Boeve-de Pauw et al., 2014). Kollmuss & Agyeman (2002) argue that external factors (institutional, economic and socio-cultural) and internal factors (such as motivations, values, attitudes and locus of control) have a synergistic impact on whether people choose to take on particular behaviours. Though the theoretical 3-part model developed by Kollmuss and Agyeman (2002) is inspired by incorporating themes and factors from the many other models they analyse in their paper, they suggest that behavioural change is unlikely to be broken down into a simple model that can authentically capture its complexity.

Building from theories before them and especially drawing from the Theory of Planned Behaviour about behavioural intention leading to behaviour, Barr and Gilg (2007) created an initial model to simply depict the links between different categories of variables and behaviour (see Figure 3).

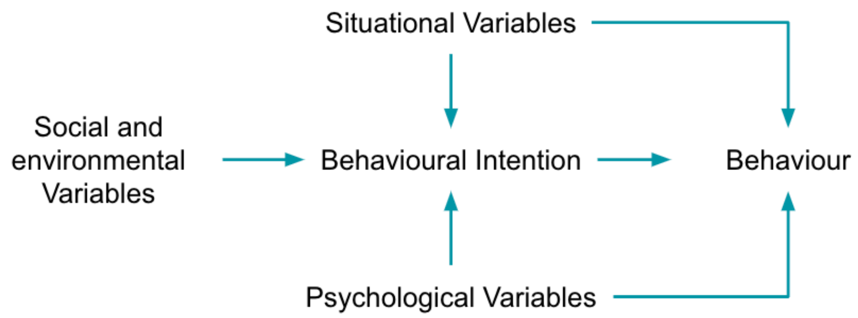


Figure 3: A representation of Barr and Gilg's (2007) simplified framework

While reflecting reality as closely as possible is desirable, the framework that was most appropriate for my educational context was that of Barr and Gilg (2007). As they developed the specific variables under the categories besides behavioural intention and behaviour, they incorporated much of the prior literature about variables like environmental values, self-efficacy, prior experience, social influence of others and motivations. They did so to illustrate detail in their model, which was supported by items in their survey. Barr and Gilg (2007) provided clear explanations for each variable, which made their framework quite operational in general and for my study's context with Hong Kong school students.

They determined the New Ecological Paradigm (NEP) (Dunlap & Van Liere, 1978; Dunlap et al., 2000) to be a suitable way to capture the environmental values as it has been used in numerous investigations, providing confidence in the data and comparability across studies (Manoli et al., 2007; Wu, 2012; Jackson et al., 2016). However, some researchers have raised some scepticism about the scale's capacity to identify the complex positions that a person may hold (Cordano et al., 2003; Mónus, 2020). I noted that the NEP scale's 15 questions lacked the ability to identify dispositions related to one's connection to nature, while certain phrases were likely not to be well understood by the range of secondary school students that would be participating in my study from local and international schools. Thus, I also considered other measurements of environmental values, namely the Nature Relatedness scale (Nisbet et al., 2009) and the 2-MEV scale (Bogner & Wiseman, 1999, 2006). The three factors of Nisbet et al.'s scale included the 'self', 'perspective' and 'experience' as part of their 21-item questionnaire. Though the NR-6 was a shorter six-item version that would demand less time for completion (Nisbet & Zelenski, 2013), the dimensions between the preservation and utilization constructs in Bogner and Wiseman's (1999, 2006) 2-MEV scale would provide the space for one to simultaneously hold values about preserving and using nature. This advantage of the 2-MEV scale allowed for the potential that my study participants may hold perspectives that were more complex than a simple binary continuum showing greater or lesser environmental worldview, typical of other scales like the NEP (Boeve-de Pauw et al., 2014).

From the vast literature about behavioural psychology and the subfield of environmental behaviour psychology, I am cognisant of the complexity inherent in the theories and models to understand how behaviour happens. Using an environmental point of view, it seems that one's position about the value of nature to humankind, attitudes about one's capacity to take environmentally-positive actions, knowledge of environmental issues and information, prior experiences with pro-environmental actions and one's intentions to act have an impact on one's actual behaviour. While considering psychological variables like self-efficacy and response-efficacy, essential components of agency (as discussed earlier), these tools are used to initiate taking various forms of individual or collection action (Bandura, 2006; Koskela and Paloniemi, 2022). Agency could be seen as elements in the process towards taking action, while behaviour is the outcome of that process. Having a strong sense of agency, while important, may not necessarily translate to measurable pro-environmental behaviour that reflects one's environmental values, which is why I felt it important to use a model that specifically examines behaviour intentionality and tangible behaviours. As such, I explain the development of my adapted environmental values scale (using Bogner & Wiseman's (1999, 2006) 2-MEV scale) and my modifications to Barr and Gilg's (2007) Environmental Behaviour Framework in greater detail in the Methodology chapter (see Ch. 4).

3.3 Impact of Environmental Education and Citizen Science on the Value-Action Gap

A study conducted by Chawla (1999) of American and Swedish environmentalists revealed that one of the greatest motivators for those adults to have gone into the environmental workforce was time spent in nature as a child. The 56 open-ended response interviews gathered factors for motivation and influences from memory recall and storytelling techniques, 77% of the participants could point to informal experiences, often tied in with family in attendance, in natural areas as the most influential factor, while formal in-classroom environmental education was 5th on the list overall. As Chawla mapped their 'life path' into effective environmental action, a pattern towards external influence after establishing one's established environmental sensitivity was seen (see Table 3):

Life-path	Childhood →	University →	Adulthood
Higher ranked factors	Experience in nature Family	Education	Organizations
Lower ranked factors	Education Organizations	Friends	Vocations

Table 3: A summary of the factors and how they changed in significance in the lives of the interviewees over their lifetime (Chawla, 1999).

The development of one's environmental sensitivity impacts their identity and motivations for taking action to conserve a place that had special meaning to an individual. Derr, a frequent collaborator of Chawla's, found that childhood time in nature, as well as experiences that meant witnessing the degradation of a natural environment was a trigger to taking action for Californian university students who participated in interviews (Derr, 2020) to determine influences for action. Though the students contributed to their communities addressing social justice as well as environmental issues, the guiding motivation hinged on how the issues intersected with their identities as activists. Hungerford and Volk (1990) studied behavioural change in adult populations from the 1980s, they pinpointed 'environmental sensitivity' as the most influential entry-level variable towards taking action, which is supported by the more modern literature.

Nature-based citizen science, with its typology of contributory, collaborative to co-created, is one such initiative that has the potential to support greater engagement of people, develop increased perceptions about preserving nature and subsequently, support pro-environmental behavioural change (Schuttler et al., 2018). Though sometimes conceptually described as a linear progression from knowledge and attitudes to behaviour (Jordan et al., 2011; Schuttler et al., 2018, Toomey & Domroese, 2013) suggest a more circular reinforcing loop of influences between the motivation to participate in citizen science projects and any resulting attitudinal and behavioural shifts. Participants in their two case-studies measuring bee species populations (Great Pollinator Project) and coyote populations (Earthwatch Coyote Project) around New York reported that just by being involved in actively collecting data for the respective projects constituted them taking action in line with their conservation values. This perception may feed into a loop that encourages participants to join more citizen science projects in the future and engage with others about the work they have been doing.

Another factor that impacts one's sense of the value of their contribution is regular communication with the scientists and organisers about the projects, intermediary results and further information on a related topic to the specific project (Brouwer & Hessels, 2019; Singh et al., 2014; West & Pateman, 2016). These behaviours show an increased involvement and consciousness about bees or coyotes related conservation issues, however, what is highlighted by Toomey and Domroese (2013) is that unrelated conservation topics aren't as prominent for the participants when it comes to attitudinal or behavioural changes. What they noted was that behavioural change was issue-specific, suggesting that links to interrelated environmental issues and potential pro-environmental behaviours need to be made explicit. As this study was conducted with self-selected adults, who were generally mostly female and over the age of 50, there is the potential that a different circumstance, such as a school classroom, may yield different results in response to action on wider environmental issues. A study by Chase and Levine (2018) showed most of their participants across eight citizen science projects reported attitudinal changes and though fewer indicated shifts in their decision-making towards more pro-environmental actions. Their participant demographics were similar to those of Toomey and Domroese (2013), and Chase and Levine (2018) acknowledge the need to broaden of the 'citizenry' beyond the wealthy, educated and those already environmentally-committed. Those who didn't show any change stated it was because they already had high levels of pro-environmental attitudes and values; indeed this was reflected in the types of volunteers who participated, as 60% were professionally involved in a nature-based or scientific monitoring field. Attitudes changes towards the specific resource or issue being monitored were felt by 57% of the participants, while positive attitudes changes towards a wider range of environmental issues were expressed by 43%, and there was a positive association between this attitude impacting their decision-making. The first-hand experience of volunteering in the citizen science project led to the attitudinal shift from the growing awareness and appreciation of being more connected to nature. While these responses to the open-ended survey questions in Chase and Levine's (2018) investigation gives credence to the various models about how beliefs, values and behaviours are interconnected and influence behaviours, such research conducted with skewed participant type (highly engaged with environmental issues) highlights the need to expand to populations that may not otherwise choose to participate in citizen science projects in their free time. Schuttler et al. (2018) synthesised the impacts of nature-based citizen science published in papers from 2014 to 2017 and found that while one's connection to nature is enhanced, there is limited consensus about the effect on attitudes and behaviour. Furthermore, they noted how very few studies they examined had an experimental research design to evaluate potential cause-and-effect, and even fewer involved citizen science with students. As such, my study about the impact of environmental (nature-based) citizen science projects on student pro-environmental values, attitudes and behaviour is even more pertinent in filling such research gaps.

This and the previous chapter introduce and bridge the literature from experiential and environmental education, citizenship education, citizen science and behavioural psychology areas. This is in service of demonstrating the context of my study and the tools I use to investigate my overall research questions. Frameworks from environmental behaviour psychology help to evaluate the impact of an experiential education activity (environmental citizen science projects) on Hong Kong students.

3.4 The Hong Kong Context

In this section, I introduce the context within which my study resides. I begin by describing Hong Kong's natural setting and formal attempts by the local government to address nature conservation. Then I introduce how citizen science projects by NGOs and academics were used to enhance environmental monitoring and support conservation attempts. Following the growth of public awareness about issues of biodiversity decline and increased pollution, an exploration of Hong Kong school-based environmental education since the 1990s is summarised to highlight challenges and opportunities. In particular, I focus on the studies that have examined youth environmental values, attitudes and behaviours, and the instruments used to measure these variables. This review of the Hong Kong context helps to identify the research gap that my study hopes to contribute to filling.

Despite the typical preconceived notion about Hong Kong as a 'concrete jungle' by visitors and locals alike, 70% of the territory is covered by natural vegetation, of which about 40% is protected as designated Country Parks under the Country Parks Ordinance since 1977 (AFCD, 2019). There are 24 Country Parks and 11 Special Areas that are located around all the major areas of Hong Kong (see

Figure 4) which are very accessible from the urban centres with public transport, and these countryside areas have attracted 11.2 - 13.4 million visitors annually since 2008.

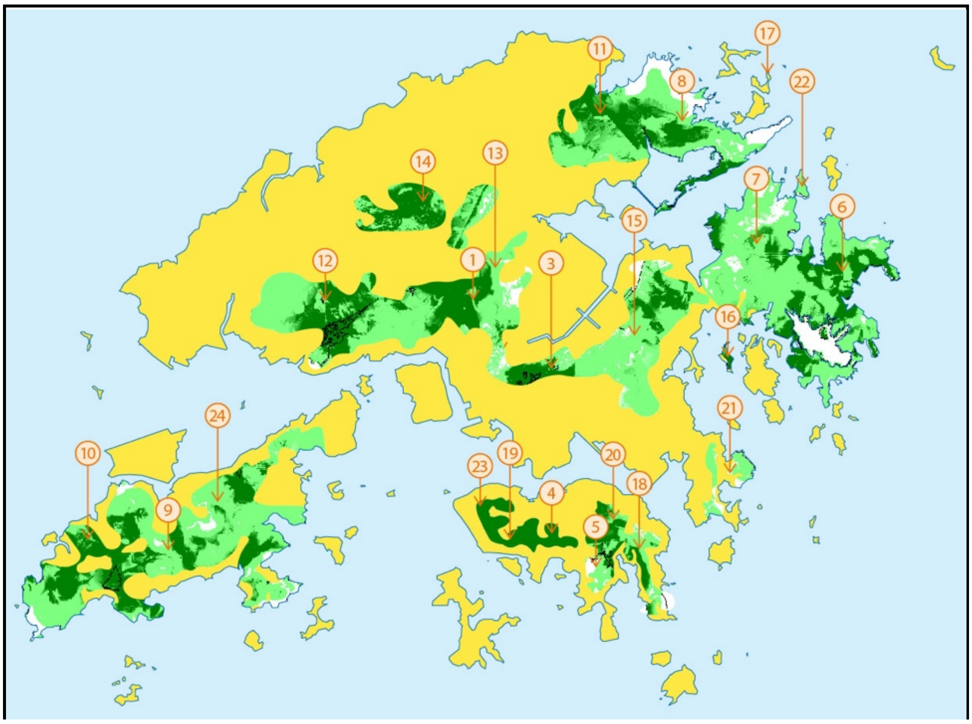


Figure 4: A map of Hong Kong (in yellow), with light and dark green shaded areas showing the 24 Country Park. Map from China Mobile Hong Kong (CMHK, 2018).

This shows great popularity and interest in experiencing the outdoors, especially with an urban area that has the 6th highest population density in the world at 26,100 people/km^2 (p. 61 in Demographia World Urban Areas, 2019) and a population of 7.29 million people (HKSAR Press Release, 2022a). Many of these parks have visitor centres within, as well as additional educational centres, gardens and arboretums that highlight the local biodiversity, history and natural resources. In addition to the Country Parks, Hong Kong also has designated marine protected areas (MPA) that have a range of protections, though only one of the now eight MPAs is a no-take zone and greater resources are required to improve the impact of the protections with enhanced enforcement (McCook et al., 2019).

The governmental arm for the protection of the natural environment across Hong Kong is the Environmental Protection Department, under the umbrella of the newly-formed Environment and Ecology Bureau (Environment and Ecology Bureau Organisation, 2022). It has a wide-ranging mission that includes creating policy about environmental protection, conservation and sustainable development, and raising public awareness about environmental issues (Environmental Protection Department Vision & Mission, 2022). One significant initiative was the creation of the 'Biological Strategy and Action Plan', a first of its kind, 5-year plan to address biodiversity conservation in Hong Kong (Environment Bureau, 2016). With a participatory approach to its development, this action plan held great promise towards Hong Kong's alignment with the Convention on Biological Diversity treaty and the Aichi targets (Environment Bureau, 2016). However, a review by the Hong Kong Bird Watching Society revealed many instances where the Aichi Biodiversity targets in the Biological Strategy and Action Plan fell short, especially for goals related to addressing underlying causes of biodiversity loss and reducing pressures on biodiversity (HKBWS, 2021). Lai (2021) offered that the high proportion of protected land afforded by the Country Parks system and a new law designating wildlife trafficking a serious crime were environmental 'wins'. However serious shortcomings from increased government-supported land and coastal developments, and the lack of financial reports about how the HK$150 million action plan budget was used, undo much of the positive gains (HKBWS, 2021). These contradictions seem to display the powerful influence of economic voices on the political will towards genuine pro-environmental progress over the voices of the concerned public.

Though various environmental government departments have implemented more environmentally-friendly initiatives, there has been a mixed response from the public to comply. Chung and Leung (2007) summarized results of attitudes and behaviour research amongst Hong Kong adults showing low levels of household recycling habits, despite expressing care for the environment, due to a lack of confidence their individual action would make an impact and personal inconvenience to sort household waste for recycling. Even 15 years later, the Hong Kong public expressed concerns and doubts that the items placed in recycling bins actually get recycled (Vanthournout & Bang, 2021). A survey found that the Hong Kong people were discouraged from recycling as they did not trust the waste system, and this distrust was founded when a separate investigation revealed more than 2/3^{rds} of plastic bottles collected at housing estates went to landfills instead of recycling facilities (Vanthournout & Bang, 2021).

More recently, as a result of the indoor gathering restrictions across Hong Kong since the start of the Covid-19 pandemic, local residents (as tourists weren't allowed to enter the territory) had especially flocked to the countryside to access fresh air and lower densities of people in the Country Parks and outlying islands (Wang, 2021). Experienced nature enthusiasts blamed the higher volumes of consumer trash along trails to those who typically did not visit Hong Kong's countryside as they would not be aware of the government-initiated practice of 'take your litter home' or the 'Green Hiking Etiquette' campaign (Wang, 2021; HKSAR Press Release, 2021). Despite campaign posters displayed across the Mass Transit Railway (MTR), a popular public transport network in Hong Kong (see Figure 5), this lack of awareness runs counter to the Biodiversity Strategy and Action Plan goals for greater public engagement and knowledge to protect Hong Kong's natural environment (Environment Bureau, 2016; HKBWS, 2021). These examples of pro-environmental engagement or disengagement reflect the public's general understanding of how to show environmental concern in a tangible way, and why, in the context of my study, investigating 'behaviour' is a useful concept.

Figure 5: A 'take your litter home' campaign poster in the 'Tin Hau' station of the mass transport railway system (photo taken by author on 16 November 2022).

Though the effectiveness of various government-led initiatives may have had mixed results, the action plan specifically mentioned using citizen science biodiversity monitoring projects to engage the public in nature protection efforts (see Action 20b, Environment Bureau, 2016). In their description, it makes clear that the Environment Bureau views the public as mainly data gatherers to support contributory types of citizen science projects, while suggesting such involvement equates to "directly involving citizens in conserving local biodiversity" (p. 75, Environment Bureau, 2016). This assumption relates back to the earlier summaries about the value of the public volunteering their time to participate in research alongside experts, and the currently inconsistent findings between participating in citizen science projects and the impact it has on one's pro-environmental values, attitudes and behaviours (see Chapters 2.2.3, 2.2.4 and 3.3).

3.4.1 Environmental Citizen Science in Hong Kong

With the opportunity for engagement in the natural environment, experts and enthusiasts alike take to the outdoors to learn about the local biodiversity. As part of the movement to support the conservation strategies embedded in these terrestrial and marine spaces, the use of citizen science has been recognised to have informative value to study human-nature interactions and impacts in projects like 'Reef Check' (McCook et al., 2019) and 'iNaturalist' (Cheng & Bonebrake, 2017).

Records show that the Hong Kong Bird Watching Society was one of the first organisations that used the citizen science approach to monitor bird migration patterns with the help of amateur bird watching members since the 1950s (Green Power, 2017). Academic institutions joined in this type of approach with the City University of Hong Kong's Department of Biology launching the "Clean Air and Lichens Project" in the 1970s to measure local air pollution, given lichen's sensitivity to SO_2 as a useful bioindicator. Projects like these have even led to positive environmental impacts in a city with tremendous infrastructural development pressures, with the Long Valley conservation campaign in 2000 being one of the most significant. Long Valley, in the northern New Territories of Hong Kong, is a migratory bird stop along the "East Asian-Australasian Flyway", a path used by about 5 million birds of 60 species (Colwell, 2010), and environmentalists including amateur bird watchers successfully petitioned the Environmental Protection Department of the Hong Kong Special Administrative Region (HKSAR) government to deny a permit for the Kowloon-Canton Railway Corporation to build train tracks across the valley. The frequency and species diversity recorded by the bird watchers showed how valuable citizen science was as a process to gather key information about potential ecological impacts, and because of this loud community voice, the Kowloon-Canton Railway Corporation was forced to build a tunnel below Long Valley, thus having no impact on the bird life above (Green Power, 2017). In addition, the attention drawn to this ecologically rich area has led to the construction of the Long Valley Nature Park starting in December 2019 (HKBWS, 2019).

One of the most recent events that triggered a wave of pro-environmental reactions was the plastic pellet spill of 2012. As a result of Typhoon Vicente generating high winds and turbulent waves that knocked six shipping containers of plastic pellets off its ship in the waters adjacent to the Hong Kong harbour, beaches and coastlines around Hong Kong were covered in a 'snow' comprising 6 million pellets, which took many weeks of clean-ups led by concerned citizens (Caliendo, 2012, Williams, 2012). This emergency led to the plastic pollution issue gaining greater public consciousness with the help of prominent international organisations like the WWF in Hong Kong, as well as the founding of a small local NGO by Tracey Read and Dana Winograd called 'Plastic Free Seas' (Caliendo, 2012). 'Plastic Free Seas' has itself developed a few citizen science projects to encourage the public to record plastic use in the form of packaging on supermarket produce and as marine trash, to address the prevalent plastic problem in Hong Kong (Plastic Free Seas, 2022).

These examples of the Hong Kong community showing concern and demonstrating pro-environmental behaviours suggest that there is some level of consciousness and action by the public when it comes to environmental sustainability. Considering that knowledge about environmental issues often begins at an educational institution (Ma, 2016), it is encouraging to see the significant shift in knowledge, attitudes and ideas for behavioural change from the 1990s to the present day, as shown in environmental attitudes research by academics in Hong Kong (for example, Chan, 1996; Jackson et al., 2016; Jackson & Pang, 2017; Yeung, 1998).

3.4.2 Environmental Education in Hong Kong

I use a chronological approach in this subsection to comment on the state of environmental education in Hong Kong as published in the literature. Early studies in the 1990s revealed that Hong Kong students show some concern for the environment, especially for the topics of wildlife conservation and the use of natural resources (Chan, 1996; Yeung, 1998). Chan (1996) created a survey using the Weigel and Weigel (1976) environmental concern scale as well as questions that included the Hong Kong context, and the three-part survey considered general attitudes, any behavioural intentions and where students obtained information about the environment. The results revealed a willingness for students to "try their best" when it came to pro-environmental behaviours related to recycling and reducing their use of tissues and plastic bags, though Chan (1996) does recognise that there is a difference between intention and actual action being taken. Despite this difference, there was a moderate correlation ($r = 0.52$) between attitudes and intention to act at the cost of personal sacrifice. At that time, students found mass media from television and radio, and school to be the major sources of environmental information, though this is likely to have shifted towards social media and the internet in the current context.

Another survey of environmental consciousness was conducted by a teacher of geography at a local school in 1993, and was more comprehensive than Chan's (1996) research as it cast a wider net of local school students across Hong Kong (not just the New Territories in Chan's investigation) with about twice the number of schools and more than twice the number of students (Yeung, 1998). Yeung's approach included a bilingual (traditional Chinese and English) two-part survey that looked at (i) student knowledge of environmental issues and their attitudes towards them, and (ii) pro-environmental behaviour they consider. The survey's knowledge component included material that would typically be covered in the Secondary 5 geography curriculum, which meant that the 2150 students who participated were all from the senior grades with curriculum experience about environmental issues. Yeung (1998) found that students were generally not very knowledgeable about environmental issues from Part 1 of the survey (curriculum material accuracy mean = 48.9%), and in contradiction to Chan's 1996 study, found students had a limited range of positive nature attitudes and their willingness for pro-environmental behaviour decreased when actions clash with convenience and encroachments in personal freedoms. Given the increasing call for addressing local air pollution as well as the prominent global events like the 1986 Chernobyl Nuclear disaster and the 1992 Earth Summit, Yeung was surprised with the result and had expected a higher consciousness. Interestingly from a cultural perspective, Yeung (1998) considered the lack of behavioural change that required physical effort and inconvenience could be rooted in the Asian sense of personal and familial welfare coming before public interest in times of conflicting needs. The blame was also given to the Hong Kong government as they were seen to do little to encourage positive attitudes and behaviour for nature and the environment.

There was great development occurring from the 1980s to the time of the student survey in 1993 that saw Hong Kong's GDP per capita increase five-fold to HK$152,087 (see Table 1 in Census and Statistics Department, 2000). This economic wealth created a rise in living standards which Yeung (1998) believed could account for the new materialistic paradigm of youth in Hong Kong. To counter the less-than-ideal levels of environmental concern, Yeung believed the opportunities lie with the Education Bureau to support teacher professional development, the creation of more environmental education resources and to enhance the policy of embedding green topics within various disciplines like geography, rather than to build a separate course explicitly about environmental education. It took more than 15 years to heed and implement the call for action by the Education Bureau, when it created an environmentally focused segment of the newly introduced Liberal Studies programme in 2009. Despite the added curricular focus, there continues to be limited opportunities for many Hong Kong students to engage in environmental education that goes beyond learning about the environment (Ma, 2016). Several local academics and environmental NGOs have continued the call for enhanced opportunities to learn for and in nature, to complement the cognitive component of environmental education (Ma, 2019). Causing a disruption to the progress, the 'Liberal Studies' course was discontinued and revamped into 'Citizenship and Social Development' as of the 2021/2022 academic year due to accusations that Liberal Studies promoted the critical thinking that instigated the 2014 'Umbrella Revolution' and the 2019 pro-democratic protests (Chan & Magramo, 2021).

The previous studies investigated secondary school students' knowledge and attitudes, though only of Chinese-speaking students attending local schools following the system culminating in the Hong Kong Diploma of Secondary Education (HKDSE). More recent studies have expanded to include students in the international schools and considered different educational systems with their varied approaches to environmental education through formal (in-school classes) and informal (extra-curricular) experiences. Students attending international schools make up only 6-7% of all the students in Hong Kong (Education Bureau, 2022), however they are the popular choice for the English-speaking community and more internationally-minded and affluent members of the Chinese-speaking community in Hong Kong. With school being identified as one of the major well-springs for environmental exposure (Chan, 1996), the question of how one's knowledge and exposure to environmental issues changes over the course of their Hong Kong secondary schooling was only researched by academics in 2016 and 2017.

Studies in the last few years have addressed some of the afore-mentioned limitations in methodology and have used consistent environmental surveys to be able to do some comparative analysis in the region and more globally (Jackson et al., 2016; Jackson & Pang, 2017). Both studies by Jackson and colleagues have employed a mixed methods approach, using the New Environmental Paradigm scale (NEP; for students 16-19 years old) and New Environmental Paradigm Children scale (NEPC; for students 11-15 years old) surveys and focus group interviews for more qualitative depth in responses about their knowledge and behaviour. The 15-question NEP scale was created by Dunlap and Van Liere in 1978 and has become one of the most internationally used assessments for environmental attitudes (Dunlap, 2008), while the NEPC was developed for older primary school-aged students in 2007. Jackson et al.'s 2016 study involved two local and two international schools with a total of 483 students and though it showed that students had pro-environmental attitudes and values (mean NEP = 3.44; mean NEPC = 3.70 out of a 5-point Likert scale), there were no significant differences between the school types nor student nationality. Socio-economic characteristics of schools impact how much financial support there is on educational resources, teacher training opportunities and experiential learning engagements, all of which are often associated with strong student achievement (Chiu & Koo, 2005), so it leaves the question as to which schools were chosen for this small study and if the socio-economic diversity between the schools was enough for a potential impact in the data.

Though there isn't any discussion about the reason, the Jackson studies in 2016 and 2017 revealed a slight gender difference with females having higher NEP values than males. Loughland et al. (2003) found a similar trend that British teenage girls were 1.5 times more inclined to have a relational concept about the environment rather than see nature as an object, than boys, though the overall concern does seem to decline the older the students get. Explanations offered include the tendency for girls being taught to demonstrate care, and hence the caring trait carries over for the environment. Though there are some differences in attitudes towards the nurturing of the environment and the selfless or self-sacrificing actions that one can take based on gender, on the whole, the transition towards the hands-on expression of that concern isn't fully understood and requires further research to determine the role that environmental educational experiences play (Jenkins & Pell, 2006).

Jackson and Pang's 2017 study involved 1383 students across 11 local and five international schools and they found a slightly higher NEP mean value (3.62 out of 5) indicating a concerted consciousness of environmental issues and a display of pro-environmental attitudes. There seemed to be a slight difference between local and international schools in the mean NEP value (local school students had greater environmental knowledge and attitudes by 0.15 in comparison to international students), however international students provided a wider range of pro-environmental behaviour and ideas for action than local students. Insights from teachers and students suggest that the teaching style differences in didactic teaching with content memorization vs. inquiry-based learning, as well as opportunities for student agency could account for some of these results (Jackson et al., 2017). These mixed results open the door for additional research investigating the way environmental education is being taught to students in Hong Kong, and what impacts, if any, occur on their values, attitudes and behaviours towards nature.

3.5 Chapter Summary

This literature review chapter built the case for using theories and frameworks from the field of behavioural psychology to consider addressing the value-action gap. It did so by explaining the development and use of a variety of theories adapted for an environmental context to understand why people act pro-environmentally. Frameworks help in understanding which situational and psychological variables influence behaviour, and I linked such ideas with measuring impact of environmental education and citizen science on the value-action gap in youth. In the latter part of this chapter, I described the use of citizen science projects to address issues of nature conservation and pollution, and explored studies evaluating the impact of environmental education in Hong Kong schools. Placing this local context within the wider phenomenon of environmental value-action gaps revealed an opportunity to investigate the potential of environmental citizen science experiences to impact how students in Hong Kong feel, think and act towards the natural environment. Without any prior studies about school-based citizen science in Hong Kong for comparison, my research offers unique insights about if and how such experiential environmental learning activities influence changes in student pro-environmental values, attitudes and behaviours. Furthermore, my investigation is pioneering a novel application of an environmental behaviour framework to measure such changes after a citizen science experience, a first of its kind in educational research. The following Methodology chapter explains how I designed and executed my extensive study with Hong Kong school teachers, students and citizen science organisers during the 2020-2021 school year, to help fill the research gap about using citizen science to shrink the environmental value-action gap.

CHAPTER 4

4 Methodology

4.1 Introduction

In this chapter I describe the research design and methodologies that guided this investigation. I start with my research rationale to provide context and justification for a mixed methods approach to study the impact of citizen science projects. This section includes my ontological and epistemological perspectives towards a pragmatist lens for the study design, and subsequent quantitative and qualitative analytical techniques. I then examine the experience with my small pilot study, the Seek Nature HK project, and discuss considerations for my main study of different citizen science projects at eight local and international schools. I detail the methodology which includes the research instruments, the fieldwork timeline and distinct considerations when working with different schools. The next subsection describes the research ethics that I followed after approval and offers reflections about conducting fieldwork during Covid-19 as it impacted my access to schools to conduct my field work. After that, I describe and explain my methods of quantitative and qualitative data analysis. I summarise the chapter with an overview of my methodology in chronologic order.

4.1.1 Main Aims

At the core of this research is my personal and professional goal to enhance the tools that educators use to engage with students in environmental education and address the environmental value-action gap. My thirteen years of working with youth in and outside the classroom anecdotally suggested that active participation in experiential education and citizen science may have an impression on student capacity to care for nature and to take pro-environmental action. As this was purely observational, my research investigation sets out to more holistically measure the contribution that experiences in citizen science can have on students' values, attitudes and behaviour. Alongside this is a running theme about the youth appetite for environmental citizenship action, from the perspectives of the youth themselves, their teachers and the citizen science organisers who they worked with. As research about local and international school students pointed to a dearth of environmental knowledge and subsequent action since the 1990s (see Ch. 3.4.2), it became clear that investigating school-based citizen science could help fill an academic gap and add to the pedagogical tool belt for educators with good practice implications. After the conclusion of the study, I aim to use my research findings and the wider literature to create practical resources for educators in Hong Kong (and beyond) to embed citizen science experiences to encourage positive pro-environmental values, attitudes and behaviours amongst their students.

4.1.2 Research Questions

The two overall research questions are (1) What is the impact of citizen science on environmental values, attitudes, knowledge and behaviours of Hong Kong students? and (2) What are the perspectives about environmental education, citizen science and citizenship action amongst teachers, students and citizen science organisers. To investigate this, the following sub-questions were developed:

1. Do citizen science experiences have an impact on student pro-environmental values, attitudes, knowledge and behaviours?
2. What are the teacher, student and citizen science organiser perspectives about environmental education and citizen science?
3. What are the teacher, student and citizen science organiser perspectives about citizenship action and pro-environmental behaviour?

4.2 Researcher Perspectives

4.2.1 Researcher Paradigm

As a result of my B.Sc. in geology and an M.Phil in earth sciences, I came to this research with a positivist mindset. This perspective guided what I considered to be objective evidence, something that could be explicitly measured in a way that produced a singular, irrefutable result. In geology and earth sciences, if there was any uncertainty about what we were calculating, there would be an expression of the potential error; for example, plus or minus x-number of years for an age determined by optical luminescence dating (something I did in my masters about earthquakes). The data was considered valid as long as trusted methods and tests were used in the analytical process. Studying rocks was one thing, but studying people was entirely different.

During my time as a teacher, it became apparent how realities could be perceived differently in the classroom. A teacher's experience of facilitating a lesson could be quite different to how individual students may have experienced it. I have noticed how cognitive factors like prior knowledge and comfort with the language of instruction, or situational factors like how much sleep did one get, or if the lesson was before or after lunch, made a difference to how lessons were experienced by students and teachers. Similarly, as I delved into the literature within environmental behavioural psychology, experiential education and citizen science, I appreciated how conceptual frameworks were needed to model phenomena that were harder to measure, compared to something in the sciences. An interpretivist perspective would partially suit my investigation into the perceptions held by my participants about environmental education, citizen science and citizenship action, however, it would not align with my use of an environmental behaviour framework as the skeletal structure for my survey items and some of my interview questions. Similarly, a critical paradigm would demand a more participatory methodology with activist or agency development outcomes for the participants. While there is the potential that my participants may reflect on their experience (being a part of my research) and register some gains in their capacity to challenge environmental justice issues, this was not an explicit intention of my current study. Understanding the human experience is a complex endeavour and while there are multiple approaches to investigate it, my dynamic experiences developed a worldview most closely aligned with a pragmatist philosophical orientation.

Pragmatists seem to worry less about the end-member positions of positivists, who trust in an absolute truth and a singular reality, or interpretivists, who believe in multiple co-constructed realities that are relative. Others working in a similar space have used a pragmatist approach. For example, Tryggvason et al., (2022) felt their exploration of student attitudes towards education for sustainable development would be best suited using a pragmatist mindset to break the notion of opposed branches of thinking about schooling and education for sustainable development. Instead of being pulled to believe in only one way of seeing and understanding reality, there is a greater focus on how one experiences reality, leading to the use of practical tools that work flexibly for an enquiry into a particular phenomenon. In Table 4, I compare some of the more common philosophical orientations in educational research that steer researchers from particular ontologies and epistemologies to appropriate research designs and methodologies. This summary involved synthesising the ideas about research paradigms by Krauss (2005), Kivunja and Kuyini (2017), and Moon and Blackman (2014). Particularly useful is Moon and Blackman's (2014) categorisation of various philosophical paradigms by research goal or application, while arranging those paradigms along an ontological spectrum for comparison (see their paper, p. 1169, Figure 1).

	Positivist	Pragmatist	Critical / Transformative	Interpretivist / Constructivist
What?	• scientific method of investigation • understand human behaviour using experimentation, reason and observation • ***Post-positivist** accepts that absolute truth is unlikely to be truly understod, but a particular truth could be probable; and it doesn't require experiments or hypothesis-testing*	• balanced and practical worldview • flexibility in methods most appropriate for observing a particular phenomenon • focuses on 'workability' in research • ideas/knowledge is true as long as they work • rejects the binary spectrum of the paradigms: positivist <--> interpretivist	• social justice research considering the following conditions leading to inequality, oppression and power structures at various societal scales ◦ social conditions ◦ political conditions ◦ economic conditions	• making meaning from understanding and interpreting what subject is communicating • reality is socially constructed (not objective) • attempt to "get in the head" of the subject ◦ maximize the subject's perspective and not the viewpoint of the researcher • context vital to understanding one's individual and unique experiences
Ontology (nature of reality and truth belief system)	• **realism (naive)**: world comprises of objects and their characteristics are often independent of perception • we take in the world based on our senses	• **non-singular**: there isn't only one reality ◦ people perceive their own unique realities	• **historical realism**: especially related to opporession	• **relativist**: accept that multiple realities exist as these are constructed between subject and researcher
Epistemology (nature of how we know truth)	• **objectivist**: findings show truth that objectively tell us about the world ◦ universal theories can be generalized ◦ context is not important ◦ truth "to be discovered"	• **relational**: researcher makes conscious decisions about the most appropriate relationships within the study ◦ context is imporant	• **transactional**: researcher interacts with their participants in thorough ways for knowledge-building	• **subjectivist**: researcher's own thinking and cognitive process is part of meaning-making through co-construction of knowledge (between subject and researcher)
Axiology (values & ethics)	• **benficence**: goal for research to benefit humanity (improving good outcomes)	• **value-laden (value-cognizant)**: research is related to benefitting people and researcher recognizes their own values at work in the process	• **respect for cultural norms:** as a social justice approach this is an important tenet to not only build trust but also establish authenticity	• **balanced**: researcher values embedded in research conclusions and findings while trying to maintain balance
Rigour (criteria for quality research)	• **internal validity:** are tested variables actually responsible for changes observed? • **external validity:** is it possible to generalize to wider contexts? • **reliability**: are the results consistent over time? • **objectivity**: is researcher bias eliminated as much as possible?	• **internal validity:** are tested variables actually responsible for changes observed? • **external validity:** is it possible to genearlize to wider contexts? • **reliability**: are the results consistent over time? • **objectivity**: is researcher bias eliminated as much as possible? • **credibility:** are data and analysis believable? Do conclusions fit with constructed reality? • **transferability:** are specific contextual details provided for others to relate study findings to their own circumstances? • **dependability**: would the same outcomes be observed under similar circumstances? • **confirmability**: can findings be confirmed by others in the same field?	• **credibility:** are data and analysis believable? Do conclusions fit with constructed reality? • **transferability:** are specific contextual details provided for others to relate study findings to their own circumstances? • **dependability**: would the same outcomes be observed under similar circumstances? • **confirmability**: can findings be confirmed by others in the same field?	• **credibility:** are data and analysis believable? Do conclusions fit with constructed reality? • **transferability:** are specific contextual details provided for others to relate study findings to their own circumstances? • **dependability**: would the same outcomes be observed under similar circumstances? • **confirmability**: can findings be confirmed by others in the same field?
Methodology (some common examples)	• **quantitative** methodologies: ◦ experimental ◦ quasi-experimental ◦ correlational ◦ causal comparative ◦ randomized control trials ◦ survey research	• **mixed** methodologies: ◦ quasi-experimental ◦ narrative inquiry ◦ case study ◦ causal comparative ◦ experimental ◦ action research	• **qualitative** methodologies: ◦ feminist theories ◦ critical race theory ◦ Freirean studies ◦ participatory emancipation ◦ postcolonial ◦ action research	• **qualitative** methodologies: ◦ narrative inquiry ◦ case study ◦ grounded theory ◦ phenomenology ◦ ethnography ◦ action research
Traits	• uses deduction / deductive logic • creates and tests hypotheses • potential for making predictions based on measurable outcomes • cause-and-effect relationship • determinism: concerned with independent factors influencing the dependent factors • empiricim: concerned with collecting verifiable empirical data, as much as possible	• also known as 'experientialism' ◦ focuses on experience-centered knowledge and change that comes from that experience • uses research design and methodology most suited for particular study's purpose: ◦ flexibility in quantitative and qualitative methods to fit purpose • focuses on best approaches to gain knowledge • potential for use in action research and praxis	• research findings seen as acts of construction instead of truth that is discoverable • uses participatory research approaches • research goal has activism components: ◦ building agency and self-determination ◦ reveal connections between politics & ethics • goal to promote social justice practices as related to human rights and addressing oppression • application of action research, focus on praxis	• theory doesn't come before research (unlike positivist which has theory first, then research), therefore grounded theory approaches for methodology and analysis are appropriate • laws are individual rather than universal • interlinked and bidirectional causes and effects • knowledge is derived from findings which contain values that need overt description/explanation • context important for methodical analysis

Table 4: A summary of four common research paradigms used in educational research.

To a researcher new to social science research, these sources were extremely helpful to comprehend how the philosophical orientations differ. However, what was lacking was a resource that posed the philosophical questions to help me decipher my position about what reality is, how to perceive and understand it. To that end, I built a decision-making flowchart that could act as a reflective exercise and answer the question: 'what is my researcher paradigm?'. The flowchart was a helpful tool (see Figure 6) for me to move from how I saw the world to how I was going to investigate it. My professional world was that of education, and my experiences as a teacher assuredly coloured how I approached investigating an aspect of experiential environmental education.

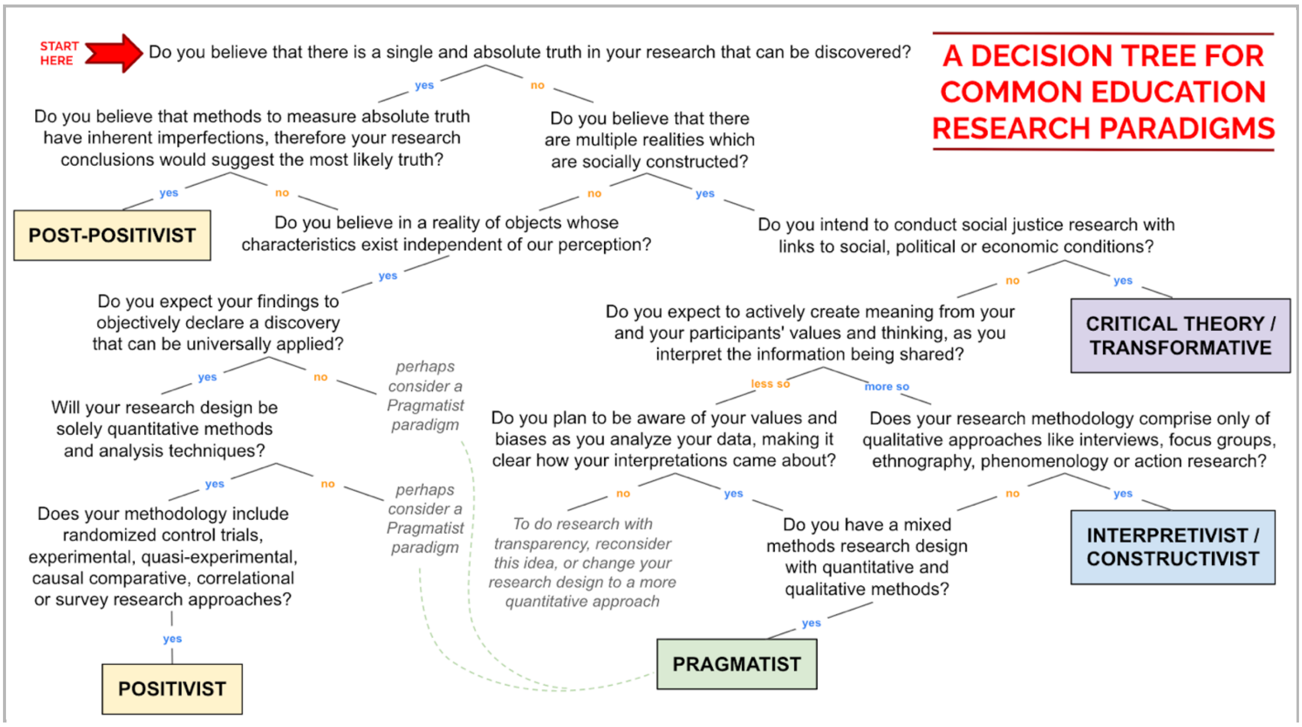


Figure 6: My understanding of some common research paradigms, in the form of a decision tree that prompted research self-reflection about reality, purpose of the research and meaning construction.

4.2.2 Insider-Researcher Position

My professional experience as a full-time teacher was in international schools in Hong Kong from 2006 to 2019. In those 13 years, I mostly taught a range of multicultural 11 - 19 year olds in geography and world issues courses. In addition, I juggled roles as a coordinator for environmental and experiential education and service learning, as a supervisor for various environmental and social issues clubs, as a sports coach for our school tennis, badminton and basketball teams, as well as a facilitator for teacher professional development. As a result of having multiple roles, I got to know the wider community of educators across local and international schools in Hong Kong. I used my network to connect with teachers and schools that have been incorporating or were open to incorporating more innovative approaches, like citizen science, to teaching environmental education, for my study.

Given my research examined secondary school environmental education experiences in secondary geography and science classes, I recognised my perspectives as a teacher with experience teaching similar classes, student age groups, and engaging with teachers in the same field, would have an impact on my communication, conduct and analysis of data. Thus, as an insider-researcher, where I investigated issues within my own professional field, I was conscious of my communication and conduct from the earliest stages of reaching out to teachers and principals, to interviewing students and teachers, to analysing the qualitative data. Especially in this kind of role, it is vital to practise ethical research (Sikes and Potts, 2008) and be aware of one's identity along the spectrum of insider-outsider researcher and its impacts on the research process (Atkins and Wallace, 2012). Being well-versed in environmental education taught in Hong Kong, having experience engaging with adolescents and teachers, and knowing how to reach out to potential schools, allowed me access and sensitivity towards participants, which Greene (2014) suggests are the benefits of being an insider-researcher. I was aware of the pressures and limited time available to teachers when designing and delivering learning engagements, so I maintained as much flexibility in the types of citizen science projects, the depth of involvement, and the time commitment required for them (and their students) to participate in my study. Having attended two secondary schools in Hong Kong during my own teenage years meant I could potentially relate with my student participants by building a comfortable rapport during the interviews in the hopes of hearing authentic and candid perspectives, and minimising social desirability bias. Social desirability bias is a phenomenon in the social sciences whereby participants deprioritise sharing their authentic perspective and instead respond in ways they think show them in good light with social norms (Holtgrave, 2004). To minimise such tendencies, I began every interview with light-hearted conversations about school, activities during the holidays and festivals that overlapped with our interview times, all the while interspersing my mostly English dialogue with some Cantonese, Mandarin and Hindi phrases, as appropriate to the participants' language. I prefaced the start of the interview with a short introduction about the structure of the interview and the various tools to be used, for expectation management. In addition, participants were informed that the goal of my research was to enhance environmental education for secondary school students in Hong Kong schools, so their honest opinions would be the most useful information to achieve that goal. In addition, I asked interview questions in a manner that encouraged more immediate responses, which Holtgrave (2004) suggests goes someway to inform the researcher that the participants spent less time evaluating how their response fits with norms about the topic and responded with a more personally true answer. These types of strategies may not stop some amount of bias, but could certainly help mitigate against it to some degree (Bergen & Labonté, 2020; Holtgrave, 2004).

While contacting schools to participate in my research, I reached out to former colleagues about getting connected with any teachers who may have an interest in conducting citizen science with their students. By not recruiting the specific schools at which I had worked, I purposefully created some distance with my student and teacher participants. This separation allowed me to have some objectivity while conducting interviews and analysing data, as well as alleviating concerns from participants about their critiques towards their schools and programs reaching their teachers. Positioning myself in this way still required consistent and frequent reflection about interpretations of participant narratives, which is a most important tool to address potential bias or being too close to one's research (Greene, 2014; Poulton, 2021). It is easy to fall into the trap of reaching early conclusions based on one's preconceptions and being very familiar with the discourse. A practical strategy that helped me maintain some critical distance was anonymising the interview transcripts, so that I was unaware at the outset if the student or teacher came from a local or an international school. Another was reading and rereading each anonymised transcript at least twice, separated by a few weeks, allowing me time to see the data with fresh eyes. Using the reflexive thematic analysis approach by Braun and Clarke (2019, 2021), which demands rigorous and iterative examination of the data, helped me address issues of objectivity and dependability, which are some main challenges and criticisms within insider-research (Mercer, 2018).

4.3 Research Design

4.3.1 Conceptual Framework

A variety of models to understand the connections between values, attitudes and behaviour exist, and an exploration of the dense literature around behavioural psychology, particularly environmental behaviour psychology (see an excerpt of my review in Appendix A), led me towards Barr and Gilg's (2007) Environmental Behaviour Framework. The foundation of this framework is rooted and developed from Fishbein and Ajzen's (1975) Theory of Planned Behaviour, and has been applied in various investigations studying the likelihood and efficacy of people engaging in green consumerism, household energy reduction, recycling, even eco-tourism, and these studies have been carried out with populations across Europe, Asia and Oceania. Barr and Gilg’s (2007) framework suggests that pro-environmental behaviour results from intentions informed by situational and psychological variables, and environmental values. This model was suitable to my study because it included an environmental values scale, situational variables (like demographics, experiences at the personal and household levels), psychological variables (like self-efficacy, intrinsic motivation), and distinguished between intention and action for the behaviour variables (see Figure 6). Understanding that many Hong Kong schools are inexperienced with incorporating citizen science in their formal and/or informal curricula, I chose to investigate any type of citizen science project experience. I did so despite considering the critique that contributory citizen science projects may overlook meaningful insights which may come from the more co-created types of projects where participant perspectives are considered (see Ch. 2.23). Through my research I wanted to test whether environmental citizen science experiences would have an impact on behaviours and reduce the value-action gap.

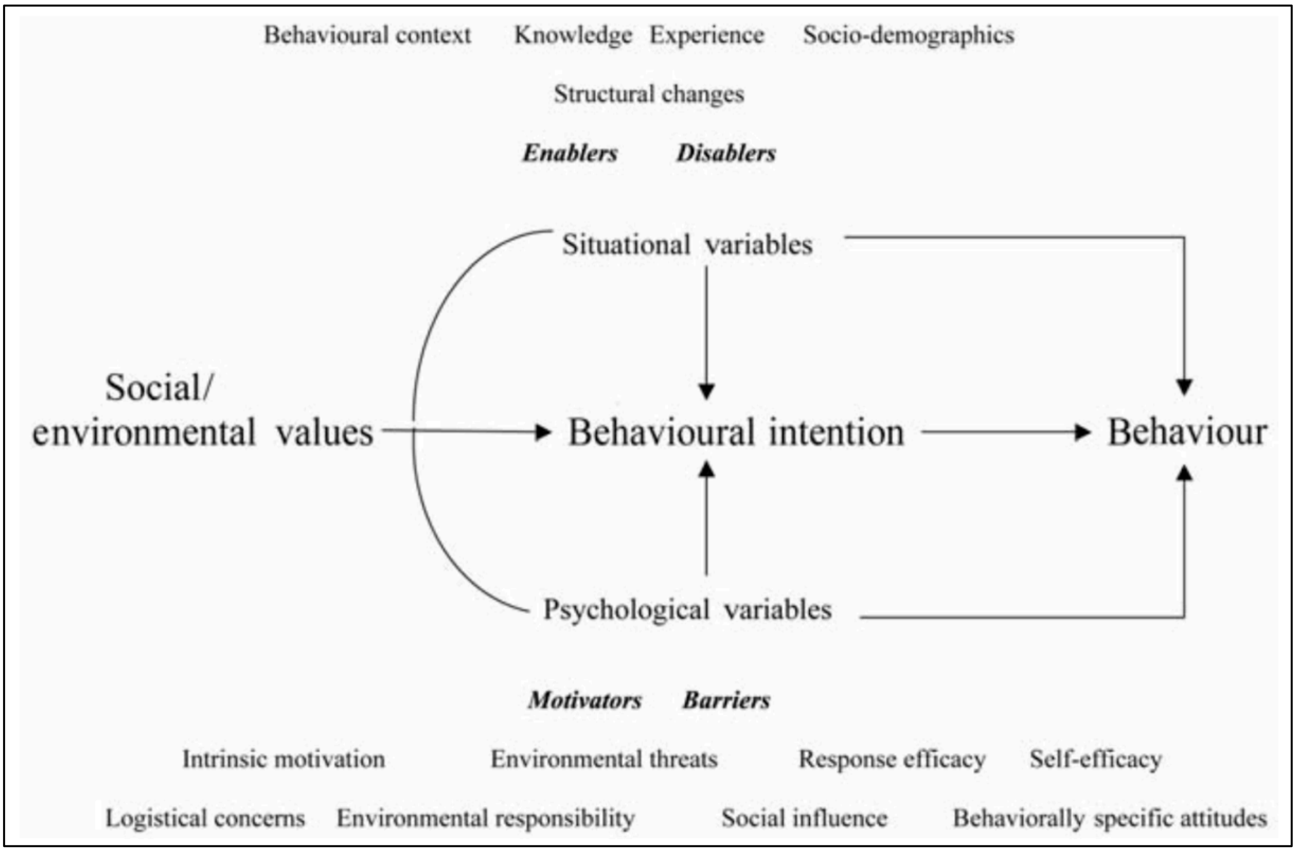


Figure 7: A detailed version of Barr and Gilg's (2007) Environmental Behaviour Framework that attempts to understand the relationships between variables that influence behaviour, as shown on p. 365 of their paper.

In general, these elements were relevant to my context of examining experiences with an environmental project. As practical as this framework was, I felt it necessary to modify it to suit the environmental educational context in Hong Kong and to connect more closely with the Hong Kong student experience. My modified framework included substituting the environmental values scale and reducing and refining the situational and psychological variables that were most relevant for measurement in my study (see Figure 8), explained further in the next subsection. This adapted conceptual model guided the development of my quantitative and qualitative instruments.

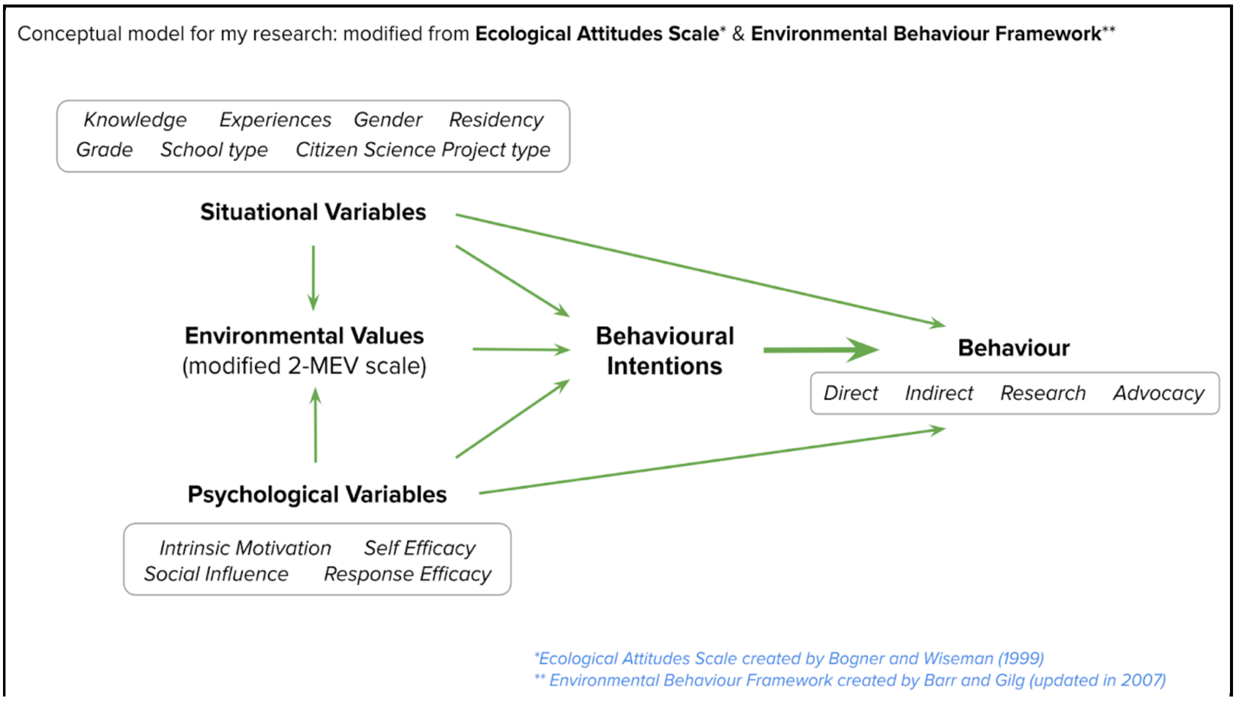


Figure 8: My modified framework, adapted from Barr and Gilg's (2007) Environmental Behaviour Framework, for use in a Hong Kong educational context about an environmental education experience

4.3.1.1 Measuring Values

The New Environment Paradigm (NEP) scale created by Dunlap and Van Liere in 1978, was used to measure environmental values in Barr and Gilg's (2007) framework. Though the NEP scale's popularity in research grew over four decades of global use, I found the fundamental paradigm to be simplistically binary (the scale forces an individual to either be more ecocentric or anthropocentric). My preferred replacement for the NEP scale was the Ecological Attitudes Scale known as the two measurement environmental values scale (2-MEV), by Bogner and Wiseman (1999, 2006) because it recognizes the capacity to hold values demonstrating care and concern for nature, as well as its use and alteration at the same time. Still, the specific phrasing of some questions in the 2-MEV scale needed further contextualising to suit the experiences and realities of youth in Hong Kong, something that other studies also did to suit their circumstances (Liu & Chen, 2019; Schneller et al., 2015), while still staying true to the preservation and utilisation components of the scale. For example, some of the 2-MEV scale items for the 'preservation' that did not suit the Hong Kong context were: (i) dirty industrial smoke from chimneys makes me angry; (ii) I save water by taking a shower instead of a bath; (iii) Sitting at the edge of a pond watching dragonflies in flight is enjoyable. Hong Kong does not have industrial complexes that creates much smoke that is visible, so this would not be relevant for students. It is uncommon to have a bathtub in the small apartments that most of the population live in, therefore taking a shower is the norm and not a pro-environmental choice. Ponds are not a common sight around Hong Kong, therefore watching dragonflies would not be an experience that Hong Kong students would relate with.

Instead of the original 2-MEV items listed above, I attempted to capture the sentiments related to pollution, pro-environmental action and nature relationships with the following way (see Table 5).

Original 2-MEV scales (Bogner & Wiseman, 1999, 2006)	**My adapted scale**
Dirty industrial smoke from chimneys makes me angry	Cleaning up the environment and protecting endangered species must be done, even if this costs money that could have been spent on supporting other important issues.
I save water by taking a shower instead of a bath	Refusing to use single-use plastic items (straws, take-away plastic cutlery, plastic grocery bags) is a useful way to take action about reducing waste.
Sitting at the edge of a pond watching dragonflies in flight is enjoyable	It is interesting to know which animals and plants exist in my community and the world.

Table 5: Examples of adaptations to the 2-MEV scale items for use in my study

Some questions were also adapted from Nisbet et al. (2009) Nature Relatedness scale, where they captured a connection to nature that exhibited values about care and concern for nature which was an element not part of the 2-MEV scale. My process of refining the questions to use in an environmental values scale can be seen in Appendix B. The final set of questions in the environmental values scale is described in the following subsection about my quantitative methods (see Ch. 4.3.2.1).

4.3.1.2 Measuring Situational, Knowledge and Psychological Attitude Variables

In their paper that details the specific components that make up the situational and psychological variables, Barr and Gilg (2007) provide a rationale that helped me determine each variable's suitability in my educational research context. Their definitions about each variable provided the basis to understand the types of questions I could pose to measure the situational and psychological variables. Keeping in mind that this framework was initially developed to understand adult environmental consumer behaviour, some elements were not as relevant for an adolescent audience (see Appendix C for excerpts of the development process). Hong Kong youth are not the ones typically making decisions about household acquisitions nor have the disposable income to do so, and are not usually involved in the logistics of managing goods coming in and out of the home. Therefore, certain situational and psychological variables, like 'structural changes' and 'logistical concerns', were omitted. For the variable of 'experience', it was expanded to distinguish what students experience as a result of being at school (and having access to field trips), as well as being a member of a household where they may be influenced by environmental behaviours around them. A study of Danish families revealed how adolescent pro-environmental behaviour was influenced by the social effect of their parents (Grønhøj & Thøgersen, 2012), so I was keen to explore the household dimension in more detail than how Barr and Gilg (2007) had in their framework. Similarly, I wanted to capture such kinds of 'social influence' in the questions posed about positive as well as negative messaging, given how youth can be affected by local news and global stories about environmental issues (Ng, 2020; Trott, 2021).

The demographic information I wanted to collect was geared towards accounting for potential differences based on student educational contexts, like the type of curriculum, the participant's grade level and gender. Additionally, the measurements for knowledge were contextualised for Hong Kong by having local knowledge questions which the youngest secondary school students would be exposed to, and global knowledge questions that would be widely known from what they learn in school and read about in social media.

4.3.1.3 Measuring Behaviour

Barr and Gilg (2007) distinctly draw attention to and measure both intentionality and acted-out behaviour in their framework. They quantified behavioural intention with 'willingness', while I chose 'likelihood', which is a more conceptually understandable term to the secondary school students (ages 12 - 19) from both local and international schools. While Barr and Gilg (2007) group their intended and self-reported behaviours into three categories of 'purchase decisions', 'habitual', and 'recycling and waste', these were not the most appropriate for the typical Hong Kong adolescent. Thus, I referenced my experiences as a supervisor for student-led pro-environmental initiatives at school and turned to Westheimer and Kahne's (2004) groupings of 'personally-responsible', 'participatory', and 'justice-oriented' citizenship actions, and Kaye's (2010) action types when creating the items to compositely measure behavioural intention and self-reported behaviour. Given the range of behaviours being evaluated, it would not be possible to gather the information in a more objective way, such as observations (Chung & Leung, 2007), so the self-reported approach was used on the survey. See Appendix C for the process to develop my modified environmental behaviour framework.

4.3.2 Mixed Methods Design

My professional experience teaching in secondary school education in Hong Kong informed my ideas about evaluating how students in local and international schools across Hong Kong respond to a citizen science intervention. My pragmatist worldviews about perceiving reality and how to make meaning about phenomena framed my choice of research design. In education research where the impact of a particular intervention is being measured, an experimental or quasi-experimental methodology is often appropriate (Cook & Wong, 2008; Dawson, 1997). As the foundations of my sub research questions are about measuring change and understanding perspectives, I would need a combination of a quantitative methodology (to measure change based on their citizen science experiences) and a qualitative methodology (to understand perspectives after their citizen science experiences). Recognising this, an ideal research design for my study would be a mixed methods explanatory sequential research design (Fetters et al., 2013). In the following paragraphs, I justify my choices to carry out quantitative pre-and-post surveys, field observations and followed by a series of qualitative semi-structured interviews, allowing the more in-depth qualitative information to supplement the condensed quantitative data.

Conducting quantitative research about the impact of an intervention is challenging because of many potential factors that could influence the results, hence the desirability of a control group for comparison (Cook, 2003; Gribbons & Herman, 1996; Marsden & Torgerson, 2012). However, creating an equivalent control group to understand causal relationships in a school setting can be problematic because it could affect timetabled routines and confront ethical protocols about common learning outcomes (Cook, 2003). Empirically the ideal control group would have matching characteristics with those participants getting the treatment or intervention, however it is highly unlikely that the diversity of local and international school students in my study would create such a suitable circumstance. At best I could have a non-equivalent control group as part of my research design to measure before-and-after intervention change (Dawson, 1997), however, as I explain in a later subsection about recruitment (see 4.3.3.3), I wanted to be open to the needs of the teachers and their school guidelines about student learning experiences. Designing a quasi-experimental pre-survey and post-survey approach around a citizen science experience without a control group does have limitations. As research design scholars have noted, there are uncertainties about the impact of the intervention itself, if there is no control group for comparison (Dawson, 1997; Gribbons & Herman, 1996; Walser, 2014). There may be other unidentified or unobserved factors influencing the measured changes, making interpretations somewhat unreliable. Within the umbrella of quasi-experimental research approaches, having a pre-survey and a post-survey protocol allows for comparison within each participant, however issues of external validity, the generalisability with the wider student population, may remain (Dawson, 1997).

4.3.2.1 Quantitative Methods

Surveys

A common instrument to collect quantitative data is with surveys (Punch, 2003) designed often with closed-answer questions. Seeking to measure change because of an intervention, especially in educational research, can be done using a pre-survey/pre-test and post-survey/post-test design (Ariza et al. 2021; Dawson, 1997; Fujitani et al., 2017), though Marsden and Torgerson (2012) highlight the need for critical reflection about potential influences of factors beyond the intervention being investigated. An advantage of quantitative surveys, such as those with Likert scale questions, is that they can provide options for quantitative analysis by creating questions with responses that could be ordinal or continuous. Being aware of the potential statistical tests one can perform on certain formats of numeric data prior to formulating a survey is a helpful planning step (Dytham, 2011). Creating survey questions that give participants the freedom to authentically express themselves, while reducing the demands on their time often requires a compromise in the number of closed-ended and open-ended questions, and may only reveal limited information (Vinten, 1995). Taking these recommendations into account, I created an analytical plan that linked my sub-research questions with specific questions that could be statistically analysed. For example, the question "Is there a change in preservation values after the citizen science experience?" could be evaluated using a related samples Wilcoxon signed rank test, which would require the 5-item Likert scale data translated into a numerical form from 1 to 5. Though the survey comprised mostly of closed-answer questions, after each set of themed questions, there was an optional open-ended question asking if there was anything the participant wanted to elaborate on.

Qualtrics was the web-based programme used to host the surveys which were estimated to take about 15 minutes to complete. The online pre-survey and post-survey share almost all the same questions in order to measure differences before and after the citizen science experience. The only questions that differed were the participant's demographic information and a question about the development of self-efficacy skills as a result of the citizen science intervention. As described in subsection 4.3.1.1, the survey questions about values towards nature, and the situational and psychological variables drawn from the adapted framework (see Fig. 7) were all built using a 5-item range of Likert scales describing agreement, likelihood or frequency. The scale to measure environmental values was a modified version of Bogner and Wiseman's (1999, 2006) 2-MEV scale, suited to the Hong Kong environmental context. I evaluated the suitability of Bogner and Wiseman's (1999, 2006) original sets of questions for their 2-MEV scale, based on what would be relevant for a secondary school student's life, their general experiences and exposure. Having worked with students in both local and international schools (though predominantly in international schools), I was quite familiar with their range of opportunities to consider, engage and take action about environmental issues. While the 2-MEV scale was used in various European, North American, African and Asian studies, demonstrating considerable relevance and inter-study comparability (Torkar & Bogner, 2019), some questions were unsuited or irrelevant for Hong Kong youth and their lived experiences in the city. For example, "Dirty industrial smoke coming out of chimneys makes me angry" is not a reality in Hong Kong because there are no smoke-producing industrial complexes. Similarly, another original Bogner and Wiseman (2006) question, "I save water by taking a shower instead of a bath" did not work because it is very rare to have anything other than a shower in Hong Kong apartments due to a lack of size (see Table 5). I conducted comparisons between multiple environmental scales with the 2-MEV and considered adaptations by Chinese researchers, to better link the socio-cultural context in which my study was based. Appendix B shows details of the comparisons across not only versions of the 2-MEV, but also the Nature Relatedness scale by Nisbet et al. (2009) and a sustainability attitudes scale by Olsson et al. (2016). In the next sub-section, I delve into greater depth about the reflections from the pilot studies and how they further supported survey development (see 4.3.2.2). The preservation and utilisation components of the values scale had five items each, with Cronbach alpha tests of the pilot study's pre-survey with 125 students across Grades 7 – 12 showing a meaningful internal consistency value of 0.760 for the preservation component and 0.673 for the utilisation component (Taber, 2018). Excluding any of the preservation or utilisation items led to a lower alpha value, suggesting that the scale was more robust with the full suite of five preservation and five utilisation survey items. The knowledge questions about citizen science, and local and global environmental information were either open-ended or multiple-choice. The environmental information questions had time limits of 30 seconds each to discourage participants from searching for answers while completing the online survey.

The paired pre-survey and post-survey responses from 187 students comprised of Likert-scale answers that were converted to corresponding numbers on a 1 to 5 scale, in the following ways (see Table 6).

Scales	Agreement	Likelihood	Frequency
1	Strongly disagree	Highly unlikely	Never
2	Somewhat disagree	Somewhat unlikely	Rarely
3	Neutral	Uncertain	Sometimes
4	Somewhat agree	Somewhat likely	Often
5	Strongly agree	Highly likely	Very frequently

Table 6: The numerical equivalent of the categorical data on the 5-point Likert scales used for statistical analysis.

The 10-item environmental values scale, adapted the from Ecological Attitudes Scale (Bogner & Wiseman, 1999, 2006) and the Nature Relatedness Scale (Nisbet et al., 2009), had an equal number of questions related to nature preservation and nature utilisation sentiments (see Table 7). The possible responses are on a 5-point Likert scale of strongly disagree, somewhat disagree, neutral, somewhat agree and strongly agree. For the complete set of pre- and post-survey questions, see Appendix D.

Nature Preservation Values & Attitudes Questions		
Enjoyment of nature	1	I enjoy being in nature (parks, countryside, beaches, gardens, forests, hills).
	2	It is interesting to know which animals and plants exist in my community and the world.
	3	My connection to nature is an important part of who I am.
Care and concern for nature	4	Cleaning up the environment and protecting endangered plant & animal species must be done, even if this costs money that could have been spent on supporting other important issues.
	5	Refusing to use single-use plastic items (straws, take-away plastic cutlery, plastic grocery bags) is a useful way to take action about reducing waste.
Nature Utilization Values & Attitudes Questions		
Alteration of nature	6	Nature must be changed or altered to feed the increasing number of humans on Earth (for example: clear forests for agricultural and animal farms, clear mangroves for fish farms).
	7	I prefer a well-cared for garden than a wild forest where plants grow in an unordered way.
Human dominance of nature	8	Human beings are more important than other creatures or biological life.
	9	Only plants and animals of economic importance and value need to be protected.
	10	Humans have the right to use natural resources any way we want.

Table 7: The final list of questions in my environmental values and attitudes scale, as part of the larger environmental behaviour framework (see Fig. 7). The overarching themes of 'enjoyment of nature', 'care and concern for nature', 'alteration of nature', and 'human dominance of nature' are from Bogner and Wiseman's (1999, 2006) original scale, which I kept for consistency.

Qualitative Methods

Interviews

A common qualitative approach in the social sciences, including education, is the use of interviews. Given the spectrum of organisational formats (individual, group, or focus group interviews) and the interview types (structured, semi-structured to unstructured interviews), the choice becomes a matter of balancing their advantages and limitations in the context of my research context.

Stemming from my pragmatist perspective and my desire for providing a worthwhile experience to my interview participants, I valued the flexibility of semi-structured interviews done individually or in small groups. While structured interviews provide greater ease for comparison across the interviews as participants are asked the exact same questions in the same order with possibly the same response choices, there is an element of forcing particular kinds of answers rather than providing opportunities for spontaneity (Morse, 2012). This may limit how participants express their thoughts and feelings about experiences in their own way, and with no room for the researcher to follow an interesting line of enquiry with probing questions, structured interviews could curtail obtaining in depth understanding

(Morse, 2012; Vinten, 1995). Unstructured interviews, on the other hand, have a light touch approach in terms of questioning and are more concerned with the participant's story while minimising any leading being done by the interviewer (Roulston & Choi, 2017). As I was focused on participant perspectives about environmental education, their citizen science experience and citizenship action, I was concerned an unstructured interview approach may lead to missing information depending on the direction and interpretation of my few questions by the participant.

Thus, semi-structured interviews were felt to be more suitable for my study needs, as I can have my questions set in advance, as well as potential probing questions at the ready, depending on participant responses (Galletta, 2013; Roulston & Choi 2017). This way a researcher can feel confident that while they are creating space for participants to share freely, the guiding questions for the investigation are also being met (Galletta, 2013). Whether they are individual or group semi-structured interviews, the flow of questions should follow a consequential structure allowing for introductory rapport-building, focused thinking, discussion (for group interviews) and communication, and finally an opportunity for overall reflection at the end (Brown & Danaher, 2019; Galletta, 2013). I intended for all student interviews to be in groups to take advantage of group dynamics, however there were some interviews conducted with individual students because of time constraints and Covid-19 impacts during the 2020-2021school year. Designing such discursive journeys with students was not an uncommon practice in my lessons when I was teaching secondary school students about world issues. As a result, I felt confident that providing guiding structures in the form of verbal questions and interactive activities during the interviews would elicit authentic participant responses about environmental education, citizen science and citizenship action.

The question guides used in the interviews were organised in a flow-chart manner, to account for some variety in responses and included potential probing questions to pose next. The questions were organised to move from big picture ideas about environmental education to impacts of their citizen science experiences and then finally, their sense of citizenship action, especially about opportunities and barriers. This was done in part for question transition clarity, as well as considering the potential directions of the conversation prior to conducting them. The questions posed during these conversations with students were designed to be a combination of student discussions based on prompts, persuasive argumentation to reach a group consensus, as well as more one-to-one sharing of information between the student and I (the latter responses were done using an interactive digital workspace using Google Slides (see Figure 9 for an example, and Appendix E). The question guide for the semi-structured interviews with teachers and citizen science organisers were in a list format that had a flow sequence addressing similar topics of environmental education, citizenship action and the citizen science experience, from the perspective of teachers or citizen science project organisers. The final subsection of questions during the teacher interviews asked them about the impact the citizen science intervention had on their own values and attitudes towards nature, as well as their pedagogical motivations to use the experiential citizen science approach.

Taking into consideration the online nature of these interviews, I adapted hands-on discussion activities for certain questions into an interactive digital version using Google Slides. These engagements allowed students to actively interact and discuss questions in ways that prompted some further thinking, especially for the questions that required consensus-building before carrying out some sorting and ranking tasks. It was also my way of maintaining interest and engagement during the interview, as capturing student attention would lead to more engaged responses. I was especially conscious of this issue because their schooling during Covid-19 restrictions meant they already were spending so many hours learning online.

Prior to each interview, I set up the personalised interactive Google Slides workspace to include the student names on the introductory slide, and for one of the individual response activities in the series of activities. This also ensured that I was organised about who I was collecting data from amongst the many interviews that I was conducting. This digital platform was chosen for the interviews because participating students and teachers were already familiar with the Google suite of tools, partly because of Covid-19 related school closures prompting online / blended learning experiences for most of the 2019-2021 school years.

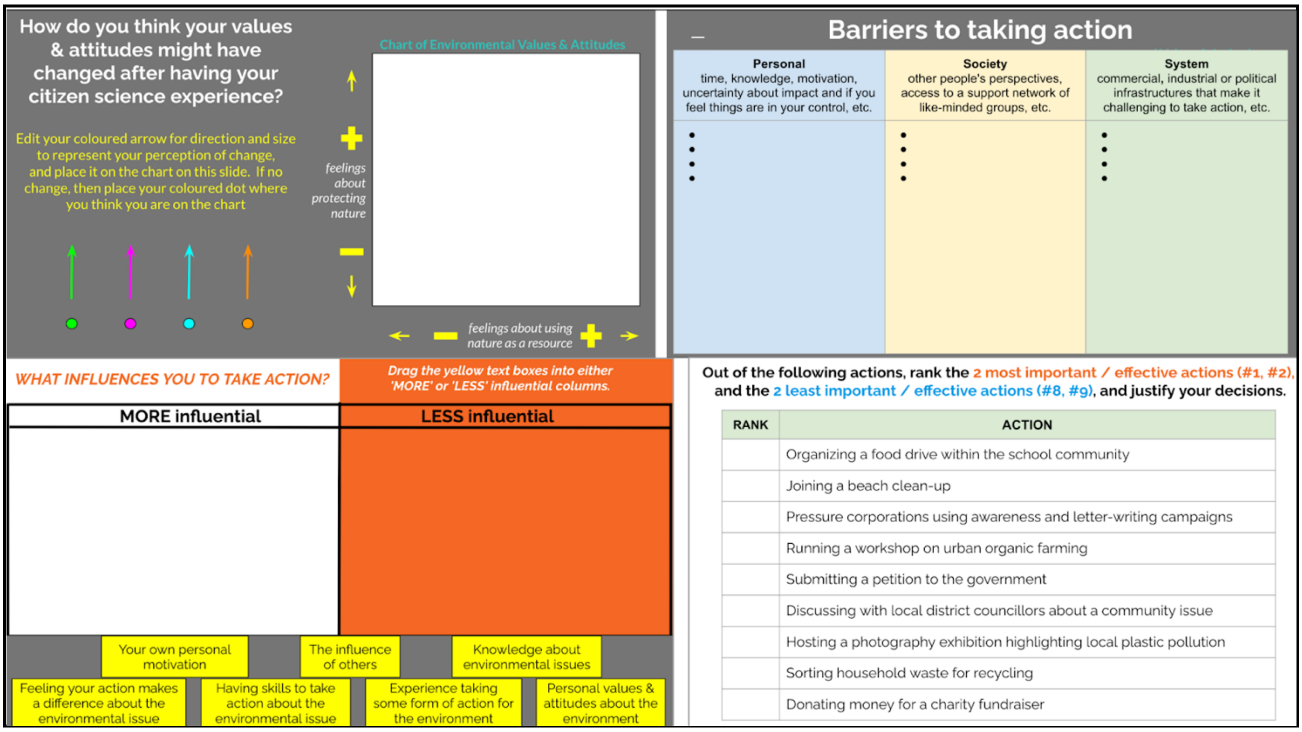


Figure 9: A four-slide collage showing examples of the digital interactive activities during online student interviews. Students could draw and brainstorm ideas to show their unique perspectives, and discuss and reach consensus in activities that required sorting, ranking, to highlight collective views and individual rationale in argumentation.

To get an idea of some lines of questioning, here are a sample from each of the three sections for the student semi-structured interviews:

- What do you think the goals of environmental education should be?
- Do you think your feelings (values and attitudes) towards the environment have changed as a result of your citizen science experience?
- What are some barriers you encounter when you want to take action?

There were some similarities in questions across the student, teacher and citizen science organiser interviews in order to carry out a comparative analysis, especially about environmental education goals, barriers to taking action and the effectiveness of particular pro-environmental actions that students can take. In addition, there were lines of enquiry geared towards teacher and citizen science organiser perspectives, such as:

- What is your impression of the impacts these learning engagements (within environmental education) have on students?
- How do you engage with the range of student values and attitudes towards the environment?
- In which ways did the citizen science experience meet or not meet your objectives and why?

The full suite of pre-survey and post-survey questions about the variables in the framework, and the interview question guide with the interactive Google Slides workspace can be found in Appendix D and E.

Field Observations

Field observations are another qualitative method appropriate for my study about the impact of a citizen science experience. Researchers have pointed out that measuring impact using surveys relies on the participant's honest reflections, yet the very nature of self-reported data collection methods means there could be some inaccuracies due to social desirability bias (Huffman et al. 2014; Paulhus & Vazire, 2007). An advantage of including field observations is getting the researcher's perspective about what the participants experience, which could help triangulate information from other data collection sources such as participant surveys or interviews (Cotton et al., 2010). Having access to real-time information is useful, especially if receiving participant reflections about their experiences happens sometime after the event and memory may be affected. Despite these advantages, Cotton et al. (2010) offer a word of caution about observations as a non-participant; the researcher's presence may alter participant behaviour, hence impacting the validity of the data collected. Offering a counter to Cotton et al.'s (2010) alert is Huffman et al. (2014)'s study with American undergraduates, noting there was a tendency to claim overly-positive self-reported recycling behaviours compared to their observed recycling actions.

The aim of conducting field observations was to gain insight about the way the citizen science experience was introduced to the students by their teachers or the citizen science project organisers, and how the students, teachers and project organisers interacted throughout the learning experience. As a non-participant, I made observations about any of the following:

- manner of the citizen science project introduction
- how students were engaging with that introduction
- logistics involved in preparing for and experiencing the activity
- nature of engagement between students, teachers and the citizen science organisers
- any teacher or citizen science organiser-led reflective discussions at the end

If there were opportunities to engage with some students who indicated they were open to interacting, the following were some field observation phase questions I was prepared to ask, which aligned with some specific situational and psychological variables in my modified environmental behaviour framework (see Table 8). I analysed any responses related to the participants experience with their specific citizen science activity using the reflexive thematic analysis technique, like the interview data, and integrated any findings in the results about student perspectives on citizen science that provided ideas or views not discussed during the interviews.

	Framework Connections	Questions
1	experience knowledge	Tell me about this activity - what are you doing? What is the larger citizen science project this is a part of?
2	knowledge response efficacy	What do you think are the goals of this particular activity and the larger project? Do you think these goals are important?
3	intrinsic motivation self-efficacy experience	What is your role in this project? Would you say you are 'doing science'? If so, how? If not, why not? As you do this activity, what things are you learning or wondering about? Would you do this kind of activity for fun on your own time (outside of school)?
4	self-efficacy response efficacy	Tell me about the skills you are using to engage with the project and the issue of *(particular issue based on CS project)*.
5	social influence experience intrinsic motivation self-efficacy	How does working in a group / by yourself (depending on how I see them working) impact your experience doing this citizen science activity?
6	response efficacy self-efficacy	*(if applicable)* How have your lessons at schools prepared you for today's activity/experience?

Table 8: The range of questions I was prepared to ask students while they were engaged in their respective citizen science activities, if the opportunities arose.

As a result of reflecting on various mixed methods approaches, my study was built around quantitatively evaluating change from pre-and-post survey data (Sullivan & Artino, 2013), and qualitatively explaining participant perspectives from reflexive thematic analysis (Braun & Clarke, 2006, 2019) of semi-structured interviews and field observations (Bryman, 2008, Cotton et al., 2010; Galletta, 2013; Morse, 2012). Other researchers interested in the impact of various environmental education interventions have also implemented similar combinations or mixed methods approaches, suggesting a growing confidence in the relevance and validity of findings from such study designs (Chen et al,. 2013; Ghadiri Khanaposhtani et al., 2022; Johnson & Činčera, 2015; Johnson et al., 2007).

4.3.3 Procedures

4.3.3.1 Research Ethics

I used the British Educational Research Association's 2018 "Education Guidelines for Ethical Research" as a guide to consider my ethical obligations as I carried out a study involving students and adults in educational occupations. The guidelines also highlighted the importance of participant choice and voice, an atmosphere of mutual respect, honest comprehension of the study goals, data privacy and anonymizing of identifying data, amongst many other considerations (British Educational Research Association, 2018). The predominant demographic in my study are secondary school students aged 11 to 19 years old, thus my ethical considerations included their safety in an online setting and a physical space, their consent to participate in any of the quantitative and qualitative methods, as well as security in the management of their data. The same protocols for asking for consent to participate in my research and following through on the data management protocols were maintained for parents (in conjunction with their children (the student participants), the teachers and the citizen science project organisers. In addition, consent was asked from the school leadership (principals or head of school, as appropriate), because one of the research outcomes is to share with them a school-specific report with analysis pertaining to their schools, in context of the overall research findings. Ethical approval to carry out my study was granted on the 27th of April 2020.

Due to the University of York's tightening of Covid-19 policies about face-to-face research, I applied for and received an exception to the research ban because Hong Kong's reality was quite different to that in the U.K. at the time. Schools in Hong Kong opened up to face-to-face and/or blended learning protocols, and some even allowed field trips during periods in November 2020 and March 2021. In-situ fieldwork in the form of observations was carried out at five of the eight school's field sites ranging from on-campus nature, near campus nature and countryside nature locations. In line with the prevailing social distancing and mask laws in Hong Kong, all the students, teachers, field trip organisers and I wore masks the entire time and maintained a personal distance of about 2 meters as the students participated in the various citizen science experiences. The other research methods remained in their online formats and therefore could still be administered as planned based on protocols in my original ethics approval document.

4.3.3.2 Pilot Phases

The original plan to conduct a complete pilot study of all my methodological instruments in May 2020 was with a group of 125 Grade 9 students (14 - 15 year olds) participating in a nature-based citizen science project to study ecology. This project and excursion had to be cancelled due to Hong Kong's second wave of Covid-19 restrictions at the time. With schools asked to close and pivot to solely online learning between early February and early June, when the school year comes to a close, the focus became to conduct a partial pilot of only my quantitative pre-survey. This survey, designed and administered using the Qualtrics survey programme, was distributed in early May till mid-June with the help of teachers in schools partnered in this research. This first pilot phase was to examine the pre-survey question comprehension, clarity and translation, and I did so at an international school that had an environmental education theme across their secondary school after their annual Earth Day focus in April 2020. Eighty-seven students ranging from Grade 7 to Grade 12 responded to the quantitative pre-survey examining their values, attitudes and self-reported behaviours towards the environment. Most of those students took the opportunity to provide more descriptive feedback about the closed-answer questions from the point of view of comprehension, ease of Likert scale use, accuracy of the traditional and simplified Chinese translations, and they also provided further rationale for their personal responses. The findings were that all the questions were clear and easy to understand for that range of students, and the Likert scales were either very easy or generally easy to interpret. No traditional or simplified Chinese translation errors were identified. In processing of the data for descriptive and statistical analysis, I needed to reconsider the wording of some of the questions about attitudes and skills. The questions about environmental values remained the same as there were no comments made about comprehension difficulties. As a result of their feedback, some phrases were edited, replacing terms with simpler words more appropriate for the younger secondary school students. However, as there was no active citizen science project that students were participating in, the pre-survey was the only instrument of my pilot that I could test.

Thus, a second pilot phase was developed to look at the efficacy of the pre and post-survey comparison and the questions for the student interviews, which led to the creation of the 'Seek Nature HK' biodiversity observation project that was active from August to November 2020. I created the 'Seek Nature HK' website (website link: https://misssmritisafaya.wixsite.com/seeknaturehk) and developed a small project involving the use of a biodiversity citizen science app called, iNaturalist. Using targeted promotional emails to local small and large environmental NGOs and youth organisations, and the snowball sampling strategy through community groups via social and print media, this citizen science initiative attracted more than 300 site visits by 205 unique visitors on the website. The project was open to any English or Chinese-speaking students who sought parental permission to participate in the surveys and interviews, and eight students (ranging in age from 12 to 18 years old) signed up by September 2020. However, due to uncertainties and expressed stress related to Covid-19 restrictions as Hong Kong experienced a third wave at the time schools began their 2020-2021 school year with blended learning, only one student managed to complete the full suite of activities: the pre-survey, the 'Seek Nature HK' biodiversity challenge, the post-survey and the semi-structured interview over a period of four weeks from mid-September to mid-October 2020. To determine the suitability of the post-survey and student interviews, I needed a larger sample size, and targeted an audience at a school with a mixed local and international population who were keen to use the same biodiversity app, iNaturalist and participate in the 'Seek Nature HK' project. Paired surveys (n = 19) and five group interviews (n = 15) worth of data revealed that questions were well understood in both English and Chinese and that the interactive workspace using Google Slides was intuitive and easy to use in interviews of up to 4 students. Research conducted about the value of pilot studies have included the improvement of not only the quality of survey and interview instruments, but also the researcher's skills in conducting the data collection, especially in the social sciences (Malmquist et al., 2019; Poggenpoel & Myburgh, 2003; Sampson, 2004). As the experience collecting data from this school proved to be fruitful and my instruments did not require any further amendments, this school's data was suitable for use as data for my main study.

At the same time as the pre-survey pilot phase, two semi-structured interviews with citizen science experts were carried out. They were representatives from an environmental NGO that has been active in using and applying citizen science initiatives in Hong Kong since 2014. This led to a refinement of the order of the questions for greater continuity and flow, and a modification to more clearly reveal the citizen science experts' perceptions of meaningful action that students can take towards addressing environmental issues, and how behavioural change occurs. I included their interviews as part of the interviews with two other citizen science organisers in my main study as they had answered the questions fully. Their busy schedules did not allow for another opportunity to interview them, and I wanted to respect their time by not asking them to repeat their interviews.

4.3.3.3 Recruitment

For the recruitment of local and international schools, I initially relied on my professional network of teachers and staff at various schools and universities across Hong Kong, and my contacts at NGOs who had previously conducted citizen science and/or environmental research projects with schools. I reached out to specific science and geography teachers, and school administrators who may be interested in experiential educational opportunities like citizen science. After introductory meetings (face-to-face, phone calls or online), I enquired with them if they knew of other teachers at other local and international schools who may also be interested in conducting citizen science with their students. At the same time, I browsed the list of schools that had participated in the Hong Kong Inter School City Nature Challenge (HKISCNC, 2019) in the previous school year, to identify which schools to connect with. This was especially useful for my local school recruitment strategy, as I needed to narrow down my search from the 451 local schools that operated during the 2020-2021 school year (Education Bureau, 2022).

Once schools and teachers were identified, I engaged in discussions with teachers to understand their curricular needs about student experiences in environmental education and the school's position about obtaining participant consent for research. I was often directed to science and geography teachers, and those who led science, nature-based or environmental afterschool programmes. Those teachers identified the most suitable classes or groups where a citizen science project would be a purposeful experience. All teachers decided that for equality in teaching and learning, all the students in those identified classes would have the opportunity to experience a citizen science project, though students could opt-in to or opt-out of being participants in my study.

The combination of convenience, snowball and self-selecting sampling strategies led to an initial list of five local and eight international schools committed to conducting citizen science projects with their students and wanting to participate in my research study. Given the unique nature of the citizen science approach, using these sampling methods allowed me to identify schools and teachers who would authentically offer valuable insights about their experiences (Newby, 2014). Based on these school's chosen citizen science projects, I reached out to their respective organisers for their consent to be participants in my study.

During this period of recruitment during the first three waves of Covid-19 in Hong Kong (from February to December 2020), it became clear when discussing with teachers about their opportunities and constraints to do a citizen science project with their students, that there could be no control group. In my own Hong Kong international schools teaching experience, I knew this to be the norm, and therefore wanted to respect the needs of teachers addressing their curricular learning outcomes and the school-specific cultures dictating student engagement opportunities. Participating schools required all students of the same course, subject or class to engage in the same learning activity. My study design could not have a subset of students in the same schools (to ensure similar population characteristics for comparison) participate in my study without having had the citizen science along with their classmates.

Due to the prevailing Covid-19 restrictions on Hong Kong school programme delivery, staff health issues and expressions of work overload, five schools opted out of participating about two months before they were due to begin their respective citizen science projects. Ultimately, three local and five international schools participated in my study. A detailed table about the characteristics of each participating school can be found in Table 16 which includes the type of school, the number of student and teacher participants, prior experience with citizen science, the types of citizen science project they were involved in and the duration of their citizen science experience.

4.3.3.4 Main Study

With citizen science as a teaching and learning tool in Hong Kong secondary schools being quite new, I decided to study the impacts of any citizen science opportunities students were experiencing. This meant that I remained flexible to include schools involved in contributory, participatory, or co-created citizen science projects, the full range of a citizen science typology. The reality of recruiting schools to participate in my study meant that some schools only had the time for one-off citizen science projects (usually contributory), while others were willing to dedicate more time and opportunities for their students to participate in on-going projects (mostly co-created). Appreciating the practical needs of schools and teachers, I acknowledged that most schools would be choosing the one-off experiences, and felt it was worth evaluating if there were differences in impact between the contributory versus co-created citizen science experiences. Keeping in mind the value of youthful experiences in nature from studies by Chawla and colleagues (for example Chawla, 2009; Chawla & Cushing, 2007; Chawla & Derr, 2012), I felt it important to include the examination of any opportunities students have in nature, with an emphasis on citizen science. All the citizen science projects used in my main study were existing projects created by experts in NGOs (contributory projects) or modified versions of existing projects to suit the teachers' or students' needs (co-created projects). In the first results chapter (see Ch. 5.1), I summarize which citizen science project each school carried out.

The research questions hinged on evaluating citizen science experiences of secondary school students and the main study was conducted between November 2020 to July 2021. The student and teacher participants came from three local and five international schools across Hong Kong's major areas of New Territories, Kowloon and Hong Kong Island (see Figure 10 and Figure 11). These schools varied in terms of the type of curricula offered (local, national and/or international), while having individual school's unique characteristics (for example, one school is for gifted students, while another is an accredited Forest School). My study involved working with secondary school students (students aged 11 - 19 years old), their teachers, and citizen science project organisers that the schools worked with in formal and informal learning contexts.

Figure 10: Distribution of the eight schools participating in my study in Hong Kong (using Google MyMaps) and the variety of the citizen science project topics about marine and terrestrial biodiversity, and forms of pollution. Note: Icon locations are in the general vicinity of the school to maintain anonymity.

Figure 11: The major areas of Hong Kong Island, Kowloon and the New Territories (from HKCSL website).

The general timeline (see Figure 12) while conducting my research at each school involved an online pre-survey one to two weeks prior to the citizen science intervention, field observations on the day of the intervention, an online post-survey about one to two weeks after the intervention, culminating in online student interviews (who identified a willingness to participate in their post-surveys) about three to six weeks after their post-surveys. The online teacher interviews were held around the same time or after the student interviews, depending on their timetabling convenience. Due to Hong Kong's multiple Covid-19 waves, school holidays and exam schedules, some interviews were conducted up to eight weeks after their post-surveys. The interviews with the citizen science organiser were carried out at their convenience, two were conducted online and two were face-to-face, anytime while their respective projects were active. The online platform for all interviews was Zoom, because of its university-vetted security features, ease of use and reliable communication tools, like the chat feature. It was also a platform that all the students and teachers were familiar with as they used it on a daily basis during the online and blended learning phases of schooling during Covid-19 waves. The Zoom recordings included separate video and audio files. I used the video recordings to verify who spoke which passages during the interviews, as sometimes it was not obvious on the audio recordings of student group interviews. Once I edited the transcripts to confirm who said what, I deleted all the video recordings and only kept the audio file copies on my password-protected laptop and a dedicated external hard-drive in a secure location at home.

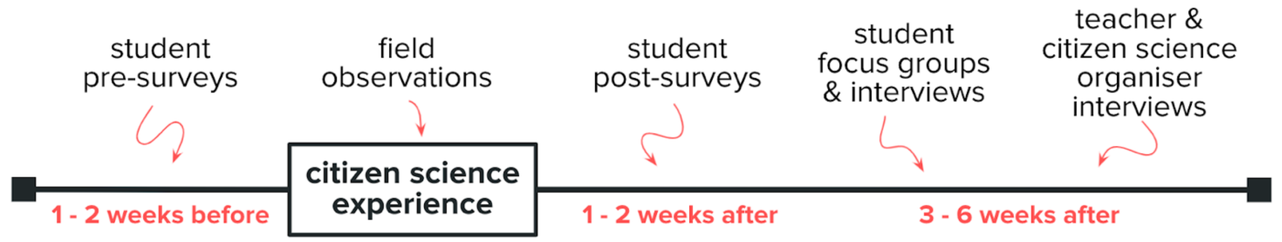


Figure 12: The entire planned phase of about 8-10 weeks per school provided flexibility for teachers to plan related lessons and make time for students to do the surveys and interviews, either during their lessons (if they chose to do it at school) or after school. Holidays, exam schedules and multiple waves of Covid-19 led to school closures which impacted when the post-surveys and interviews were actually completed.

Surveys

The link to the online pre-surveys were provided to teachers about a month before their scheduled citizen science activity. The link to the online post-survey was given to teachers a few days after their citizen science activity. Each time, the teachers were responsible for sharing the respective survey links directly with their students. A total of 421 students fully completed the pre-survey and 282 students fully completed the post-survey, producing an initial attrition rate of 33.0%. There were 95 students who did the post-survey but not the pre-survey, thus leaving a total of 187 paired survey participants, giving a final paired response rate of 44.4% (see Table 9). There were 115 incomplete pre-survey responses and 54 incomplete post-surveys responses, and these were excluded from my descriptive and inferential statistical analyses.

School	Pre-surveys		Post-surveys	
	Incomplete	Complete	Incomplete	Complete
1	4	21	5	18
2	47	227	23	174
3	0	21	6	18
4	5	40	2	26
5	59	86	12	19
6	0	7	3	8
7	0	10	3	11
8	0	9	0	8
Totals	**115**	**421**	**54**	**282**

Table 9: The number of incomplete and complete student pre-surveys and post-surveys from each school

Field Observations

Out of the eight schools that participated in my study, I was able to visit the citizen science project sites of five schools to conduct field observations of students and teachers. The three schools where I was not able to make observations were because of the projects being purely online during their school classes or Covid-19 restrictions made access to the schools not possible. Some schools engaged in biodiversity citizen science projects on campus, while others investigated coastal and terrestrial biodiversity and pollution just off-campus or further in the rural parts of Hong Kong's outlying islands. In some cases, the project was created and partly delivered by project organisers from an environmental NGO. In the remaining situations, the teachers would lead the activity. In all circumstances, I had minimal initial contact with the students and teachers, other than being introduced by the teacher leading the activity about my role as a researcher looking at environmental education experiences in different schools across Hong Kong. During the activity, I would try to find the least obtrusive ways to pose appropriate field observation questions (see Table 8), though for the most part the students were quite focused on the activity and sharing results with each other and their teachers than engage in my questions.

Interviews

While the pre and post-surveys provide breadth, interviews allow for greater depth (Galletta, 2013). The group interviews occurred after the post-surveys and I purposefully designed them to be semi-structured, with occasions for more discursive responses between participants. Part of the interview involved participants working in a digital workspace where exercises such as sorting and ranking required discussion to build consensus. These interviews were designed to be conducted in groups of no more than four participants at a time, however, scheduling limitations meant that some interviews had only 1 participant (see Table 10).

Participant Type	Number of Participants	Number of group interviews	Number of individual interviews
Students	46	12	12
Teachers	18	9	3
Citizen Science Organisers	4	0	4

Table 10: The breakdown of the total number of participants, and number of group and individual interviews.

In total, I conducted interviews with 46 students (13 local and 33 international), 18 teachers (6 local and 12 international) and four citizen science organisers. Though the interviews ranged from 40 minutes to 2 hours in length, most interviews took about 65 minutes. The group interviews, especially with teachers, generally took longer than the individual interviews due to the additional participants. On the rare occasions where a participant had internet connectivity challenges and trouble using the video or audio functions, they reverted to typing their responses in the chat. To encourage their participation while their peers spoke, I would audibly invite them to share their opinions and repeat my invitation as written text in the Zoom chat function. This was done to reiterate the value of their contribution, despite technical issues, and to signal to their peers that I gave importance to all participants' perspectives. The chat feature came in handy for one interview with a student wearing a hearing aid, and I typed English and traditional Chinese character translations to each question, while also saying the questions in English aloud during the interview. Most of the time they responded verbally, using the chat feature on occasion to provide responses in Chinese which I translated using Google Translate immediately. This language support proved to be another advantage of conducting online interviews.

4.4 Methods of Data Analysis

With this investigation being a mixed methods study, there needed to be a clear plan for analysing the quantitative data from the surveys and the qualitative data from field observations and interviews. The variables in the environmental behaviour framework were built into the pre- and post-surveys such that descriptive and inferential statistical tests were performed. The qualitative data was explored using the reflexive thematic analysis approach, with a consciousness about my pragmatist and insider-researcher perspectives.

4.4.1 Quantitative Analysis

I used the IBM SPSS statistical programme for all descriptive and inferential statistical tests on the survey data. I followed the practice of treating summations and ratios of Likert scale data as continuous variables (Sullivan & Artino, 2013) and tested the pre-survey and post-survey data for normal distribution using Kolmogorov-Smirnov and Shapiro-Wilk tests. Most of the variables show results that require rejecting the null hypothesis that my data behaves like a normally-distributed data set (see Table 9), therefore nonparametric statistical tests, like a related samples Wilcoxon signed rank test, would be the most appropriate route for analysis (Dytham, 2011). Parametric tests like, two-tailed paired-sample t-tests, would be suitable for Likert scale data if the items were summed to make a total score and were found to behave normally (de Winter & Dodou, 2010), however, with the exception of the Behaviour variable, all the other variable totals did not show normal distribution (see Table 11).

Variables (Pre-survey/ Post-survey)		**Kolmogorov-Smirnov test**		**Shapiro-Wilk test**	
		Statistic	Significance	Statistic	Significance
Preservation	T1	.111	<.001	.941	<.001
	T2	.108	<.001	.946	<.001
Utilisation	T1	.105	<.001	.976	.005
	T2	.079	.012	.974	.003
Intrinsic Motivation	T1	.147	<.001	.938	<.001
	T2	.152	<.001	.943	<.001
Social Influence	T1	.152	<.001	.947	<.001
	T2	.181	<.001	.929	<.001
Response Efficacy	T1	.154	<.001	.950	<.001
	T2	.160	<.001	.948	<.001
Self-efficacy Importance	T1	.149	<.001	.874	<.001

	T2	.126	<.001	.915	<.001
Self-efficacy Development	T2	.137	<.001	.944	<.001
Confidence in Self-efficacy	T1	.096	<.001	.950	<.001
	T2	.094	.001	.968	<.001
Personal Experiences	T1	.092	.001	.984	.051
	T2	.094	.001	.979	.012
Household Experiences	T1	.078	.014	.984	.047
	T2	.128	<.001	.978	.010
Local Knowledge	T1	.215	<.001	.897	<.001
	T2	.174	<.001	.920	<.001
Global Knowledge	T1	.216	<.001	.807	<.001
	T2	.224	<.001	.809	<.001
Total Knowledge	T1	.157	<.001	.944	<.001
	T2	.126	<.001	.957	<.001
Behavioural Intention	T1	.105	<.001	.970	.001
	T2	.092	.002	.968	<.001
Behaviour	T1	.062	.200	.989	.208
	T2	.070	.044	.988	.153

Table 11: A summary of the Kolmogorov-Smirnov and Shapiro-Wilk tests for normality of the variable totals from the pre-survey (T1) and post-survey (T2) data of the total 187 paired samples.

To be thorough in analysing change as after a citizen science experience, both the two-tailed paired samples t-tests (parametric) and the related samples Wilcoxon signed rank tests (non-parametric) were applied to the dataset with statistical significance defined as $p < 0.05$. Though Mircioiu and Atkinson (2017) concluded that Likert responses from over 15 participants have similar significant or not significant results when comparing findings from both parametric and non-parametric tests, and I opted to stay on the more conservative side, and report and analyse the non-parametric Wilcoxon signed rank test results. In addition, when comparing between groups of participants based on school type, citizen science project type and other demographic parameters, the sample sizes may significantly differ, and using non-parametric tests has been shown to provide meaningful and valid results (Harpe, 2015). This decision was made even though my sample size significantly exceeded their threshold ($n = 187$) and I noticed the same t-test and Wilcoxon test result observations as Mircioiu and Atkinson (2017). As there is much discussion about the most appropriate tests for normality with different sample sizes and range of statistically power (Harpe, 2015; Yazici & Yolacan, 2007), treating my data as not normally-distributed reflects the reality that my sample of students have knowledge and experience in the topic of my investigation, and may not behave like the wider population. The data having a skewed distribution does not take away from the robustness of the analysis that can be performed on the data, and the conclusions derived from the results (Mumby, 2002; Norman 2010).

To measure if there were any statistically significant ($p < .05$) changes between the pre-survey and post-survey data for each variable, I used the related samples Wilcoxon signed rank test. In the following results chapter, I report the test statistic (W), the p-value (p), the effect size (r), the probability of superiority (PS) statistic and the sample size (n), based on recommendations for thorough statistical test reporting practices to demonstrate the statistical power of the results (Chase & Chase, 1976; Fritz et al. 2012; Kanyongo et al., 2007). The Wilcoxon test statistic, W, and the *p*-value are provided as outputs of running the related samples Wilcoxon signed rank test in the SPSS programme. I used Cohen's (1988) effect size formula for Wilcoxon tests, $r = Z / \sqrt{N}$, where Z is the z-statistic provided as part of the Wilcoxon test, and N is the sample size doubled (because there are pre-survey and post-survey observations). Though the *p*-value provides a statement of statistical significance, calculating effect size is an important component to understand how meaningful the result is, while determining the PS statistic reveals the likely percentage of the population that would feel the effect being tested (Fritz et al., 2012; Mumby, 2002; Prajapati et al., 2010;). Cohen's (1988) small, medium and large effect size categories are the benchmarks that I used to describe the effect sizes of my results. I chose to follow what Schäfer and Schwarz (2019) call the 'conventions' approach for using Cohen's construct, rather than the ‘comparisons' approach, due to a current lack of established effect size standards in environmental behaviour psychology studies in an educational setting.

Another line of enquiry in my research is about which framework variables influence pro-environmental behaviour. To examine the interaction of independent variables on the dependent variable (behaviour), multiple linear regression analysis was conducted (Chung & Leung 2007; Dytham, 2011; Harpe, 2015). In the results chapter, I report the p-value (p), R-squared (R^2), adjusted R-squared (adj. R^2), variance inflation factor (VIF), effect size (f^2) and sample size (n). Other studies examining the potential predictive power of variables to influence environmental values, attitudes or behaviours used regression analyses (Janmaimool, 2017; Kibbe et al., 2014; Ma et al., 2021; Meinhold & Malkus, 2005), so this approach was also suitable for my study about environmental values, attitudes and behaviour.

4.4.2 Qualitative Analysis

With the range of approaches to analyse qualitative information, I considered techniques that aligned with my pragmatist paradigm and my insider-researcher position. Wearing the hat of someone with experience teaching in Hong Kong international schools, I acknowledged how this would influence my interpretation of the data as I search for patterns of meaning (Boyatzis, 1998; Braun & Clarke, 2020;

Fereday & Muir-Cochrane, 2006). To understand teacher, student and citizen science organiser perspectives about environmental education, citizen science and citizenship action required that I maintain an open mind to their experiences and ideas, therefore a thematic analytical approach would be suitable. As Boyatzis (1998, p.4) describes, thematic analysis is a "way of seeing" and a "way of making sense" of information to understand some phenomena. Specifically, Braun and Clarke's (2006, 2021) reflexive thematic analysis technique would be appropriate because of the analytical rigour demanded of the researcher to continuously reflect on one's interpretation of the qualitative data, considering their paradigm and position. They specifically caution researchers that a reflexive approach is at odds with passive notions of themes lifting off pages and emerging from the data (Braun & Clarke, 2006, 2020, 2021). I appreciated how this technique required the researcher play an active role in interpreting the data from an acknowledged perspective. Various researchers exploring questions about student and teacher perceptions about science or environmental topics have published insightful qualitative findings using the reflexive thematic analysis technique (Keith et al., 2022; Rushton & Reiss, 2019; Waldron et al., 2019), suggesting Braun and Clarke's (2006, 2021) tool would be appropriate for my topic as well.

For accuracy, I transcribed the 64 interviews verbatim (46 students, 18 teachers and four citizen science organisers). As all the interviews were conducted in spoken English, with minimal written Chinese communicated in Zoom's chat function during one student's interview, there was almost no translation required. I did so with a combination of playback recording and transcribing, and with the auto-transcription program, 'Otter.ai'. I reviewed and edited the transcripts of interviews processed by 'Otter.ai' for accuracy, while listening to the recordings to ensure that I was capturing the true meaning of what was being said (Poland, 1995). The transcriptions amounted to 530 pages of about 280,000 words in participant responses. Analysing this quantity of qualitative data required the help of a data analysis software, and I used QSR's NVivo for Mac (version 20) to assist in the organisation of my analytical process. To begin the analytical process, I read a handful of transcripts and made notes about the content of participant ideas and potential avenues to interpret them. I used an inductive, and open and complete coding approach as I created many semantic and latent codes from participant meanings and ideas (Braun & Clarke 2020, 2021). While staying receptive to what the participants shared during the interviews, the variables in my adapted theoretical framework (see Figure 8) were key ideas that I looked for in the transcripts and meanings. Though the framework was precisely used to guide the exact components of the pre and post-surveys and to guide the quantitative analysis, the variables were just as important and necessary to support the interpretative work of qualitative analysis of the interview transcripts, thus lending to greater integration of findings for this mixed methods study. For example, one question posed to students on the topic of environmental education, "What kind of impact do those experiences (school-based environmental education activities) have on how you think about and act towards the environment" (see Appendix E), had responses that connected to the framework's psychological and situational variables like preservation values in 'environmental values', intrinsic motivation', 'knowledge' and 'personal experiences'. When I enquired about the effect of their respective citizen science experiences, I noted references to the psychological variable 'response efficacy' when they described impacts on their skills such as research, planning and team work. A worked example by Byrne (2021) was particularly helpful in outlining how to move across the reflexive thematic technique stages. This non-linear and iterative process of coding was dynamic because of changes in codes as I read and reread each transcript at least twice. I categorised my codes into general groups linked to my sub research questions and ultimately refined these ideas into themes and sub-themes, using my framework variables to draw attention to key ideas and concepts. I generated a total of 125 codes across the teacher, student and citizen science organiser interview transcripts. This led to the development of 121 sub-themes to capture the breadth of ideas and perspectives from participants, and the creation of 37 themes to summarise and focus on the most relevant patterns of meaning related to my sub-research questions from all 64 interviews. This thorough process led to the distillation of the most salient key themes which encompass the complexity of the breadth and depth of quantitative and qualitative findings in this mixed-methods study (see Ch. 8).

Examples of the output of this process are presented in tables that show themes, sub-themes, codes and the linked interview excerpts (see Table 12, Table 13 and Table 14). There is one example each from teacher, student and citizen science organiser perspectives.

For instance, in Table 13, a student shared an experience from a humanities lesson," ", and I interpreted the excerpt as one demonstrating an influence on how their preservation values and intrinsic motivations (variables from the framework) were developing. I inferred the reflective nature of their statement and saw a critical thinking process at work, which I coded as 'critical thinking and self-reflection to take action'. As a result of the personal nature of their self-reflection, I concluded this coded excerpt was addressing deeper expressions about one's connectivity to environmental stimulus. As such, the sub-theme I drew out was "How does the issue relate to me", which ultimately led to the creation of a theme that drew upon codes about the value-action gap and taking action, "Me, Myself and I".

Theme	Sub-themes	Codes	Excerpts
Raising the bamboo scaffolds	Age-appropriate and scaffolded content knowledge	Knowledge - science literacy development	*So they aren't necessarily experts within fields, but they, um, they have a laymen understanding... is one in which they remain literate in science.* *Everyone is scientifically aware, like, you know, have a basic understanding of science.*
		Knowledge - environmental literacy development	*I think their knowledge about about the plastic pollution should be increased.* *I mean I, to be honest, I really think these things kind of have to be scaffold it from you know from preschool and you know just like you learn about life cycle of a frog we feel like we should be doing life cycle of things You know just adding more complex layers as they get older.*
		Goals - science education	*What could you do to improve on, on your, your ways of living, and we generate conversations about other things happening elsewhere in the world? And as I mentioned earlier, where they don't have the ability to make the decisions or the impact themselves, and whose responsibility is it to have that kind of impact in generating new laws or enforcing policies*
	Critical analytical skills to process complexity	Knowledge - science literacy development	*I want to add a point in terms of like, you know, the repetitive nature of actually carrying out your fieldwork. It changes your perspective, because now when we're looking in class about a study that's done, they just don't see face value as a piece of paper and a study and I just need to read that this scientist did this, they now know the amount of work that must have gone in to make a conclusion, and then that conclusion must be valid if they're to do that. So that was good for them to experience.*
		Environmental education goals (teacher)	*having the ability to analyze information, they've a complex understanding of systems that are interconnected, um, and… three other skills… and they have the ability to be skeptical, make decisions on their own. That's a massive part in the world right now, is that people really struggle with the ability… and that's the part about understanding complex systems, and then secondly is that, being able to evaluate data, and the information coming at them from media, to make decisions on their own*
		What teachers do to create science literacy	*if you think about how we holistically approach kids, we teach them enough and we teach them how to critically think in the field of science, so that they remain laymen so that they can interact with the world around them, with those skills.*
	Universal content standards	Environmental education goals (teacher)	*So I think it's extremely important to have very good baselines for students to reach.* *I think that the the main point is that all the students, they are basically on the same level. So in the future, some totally aware.*
	Support exam success	Educational outcome	*And yes, you got to get the students to pass the examination the end of the day, but that's not the be all end all. That's not what's going to give them hopefully, the skills they need to progress in life.*
		Goals - environmental education	*We also think that for education we shouldn't focus on something, just only focus on examination. In our school, we would like to use more activities for our students to get involved.*

Table 12: Example of how excerpts, codes and sub-themes fit in the theme 'raising the bamboo scaffolds' for teacher perspectives about environmental education.

Theme	Sub-themes	Codes	Excerpts
Me, myself and I	Does the issue relate to me?	Critical thinking and self-reflection to take action	*In that geography, we had to watch a documentary. It made me think about how I set my own actions and how it affects environment. Because since the earth is practically your home, you want to keep, you want to keep it healthy and clean. Because if it's dying, that means you lose your home.*
		Value-action gap	*I care a lot about animals and I really want to help them.*
		Actions - what people are willing to do	*There was a time around the summer, when I learned about like, the air conditioning can affect the environment. And then since it was summer, I tried to like, decrease the amount of air conditioning that I use.*
	Can I take action myself?	Tangible direct actions has greater meaning or impact than other actions	*I think direct is the most easiest, and can make the most impact because like small things like recycle, we can do it every day, but it can have a big impact to the environment. So I'll do more of directed direct actions.*
		Youth priorities eclipsing environmental mindedness	*In primary school, I remember that some of the students helped set up a mini like garden and when some lettuce and some other vegetables in the garden, but then I don't think that's it... I think it was a nice small scale gesture, but I don't think it's had a great impact on me because I, I don't, I don't think that I would just have the time or ability to tend to, or even the, the resources, you know*
		Value-action gap	*So like recycling is like the simplest. It's like the simplest thing I could do. I guess I could do do more.*
	Will I feel like I've made an impact?	Tangible direct actions has greater meaning or impact than other actions	*For example, for beach cleanup. After I clean up the beach, the beaches will be clean. And I see that the environment is being like, it's improving, because of me, that I'm making a positive change.*
		Does raising awareness lead to action?	*Maybe you're hosting some photos of how you're helping, and like, you might be an influencer and this will definitely help a lot of other people. Other people will help you.*
		Direct action has more meaning than supporting others taking action	*You might say "oh yeah, I donated to charity", but then if you actually done it yourself, like for example, planting trees. and then you planted the tree yourself, it has more meaning to it.*

Table 13: Example of how excerpts, codes and sub-themes fit in the theme 'Me, myself and I' for student perspectives about citizenship action.

Theme	Sub-themes	Codes	Excerpts
Pedagogical Swiss army knife	Adaptable teaching tool	Educational outcome	*Just a different way for teachers to actually teach ecology and biology as part of their curricula. We wanted to have this competition to have that aspect, so there was an education perspective. From that education perspective, use this data as part of project based learning or experiential based learning.*
		Engaging with nature	*I'm to contribute to biodiversity monitoring, all I have to do is to take pictures on my phone, alright I can do that. Rather than getting involved in... it's like, what I call, the base level of citizen science. And from that you get involved in nature... you might be a little bit more agreeable to getting involved with more stringent biodiversity monitoring. Maybe using proper ecology techniques, like line transects, all that type of stuff.*
		Educational outcome	*Every teaching is different, just like every school is different, every student is different, however offering teachers a different way of illustrating, if you like, how citizen science and citizen science tools like iNaturalist or Seek can actually augment or enhance the learning experiences that students have. Also enhance things like critical thinking, civic responsibility, moral studies, all that type of stuff. The cross curricular potential of citizen science can be explored.*
	One size fits all	Educational outcome	*It's quite flexible - every school is different, every school has a different budget, resources, sizes, levels of students, so there will be different things that schools can or cannot do. Ultimately it is offering the framework and letting the schools 'fill the house' in any way they like, so I never dictated to anybody.*
		Citizen science impact on values and behaviour	*Marrying citizen science with the society, so of course it doesn't have to be the environment or biodiversity, it could be about other stuff, but how that actually trickles down to a positive effect on society.*
	Retool the teacher	What would make citizen science experiences better	*I think if there will be a follow up afterwards, maybe that would be better. I mean follow up specific to that school. And that would help the kids I don't know if the teacher is doing or maybe [the NGO] could help to guide them.*
		Educational outcome	*We hope to use the scientific method to engage the public to involve them in the scientific training. Sometimes when we want to connect the people to the environment, we need to do some practical training. So citizen science survey is a kind of practical training for them.*
		Educational outcome	*I think citizen science is a brand new and effective education approach, because we can really educate them in reality instead of theory. I support experiential learning. Three hours in a lecture vs. one hour in the field, you cannot compare.*

Table 14: Example of how excerpts, codes and sub-themes fit in the theme 'Pedagogical Swiss army knife' for citizen science organiser perspectives about citizen science.

I present my quantitative and qualitative findings to answer each of the tree sub-research questions, with one chapter per research question. While the first research question asks about the impact of citizen science experiences and relies mostly on the quantitative data from the survey, I include qualitative findings as they relate to the specific finding being discussed (see Ch. 5). In Chapters 6 and 7, which correspond with the second and third sub-research questions, qualitative data is the dominant source of the findings with some quantitative information used to support my arguments. Taken together, these components build a robust set of broad, deep and diverse findings to provide an overall answer in my mixed-methods study about the impact of environmental citizen science in an educational setting.

4.5 Chapter Summary

In this chapter I explained how my researcher paradigm influenced the design of my study to answer my research questions. The procedures I chose were based on the literature about the most suitable quantitative and qualitative techniques for a mixed methods explanatory sequential approach in an educational setting. With inspiration from environmental education and behaviour psychology research, I modified an environmental behaviour framework to use as a structural guide to design the survey and interview questions for my quasi-experimental investigation around a citizen science project. I described the stages from my multiple pilots to my main study, while indicating how Covid-19 impacted various aspects of my research design and execution. An examination of the literature around techniques for statistical and qualitative analyses supported my choices for related samples Wilcoxon signed rank tests and multiple regression analysis for my survey data, and reflexive thematic analysis for the interview information. Table 15 outlines my process about the procedures and the subsequent outcomes that guided the proceeding steps as I executed my study.

PROCEDURE	DETAILS	OUTCOME
Literature review of studies about citizen science impact, and behaviour change research	• examined various behaviour models • evaluated different environmental values scales	A modified environmental behaviour framework to guide development of the survey and interview questions.
Designing methodological instruments	• created pre and post-survey questions • created semi-structured interview questions	A completed set of closed and open-ended questions for the surveys, and an ordered set of open-ended questions for the semi-structured interviews for teachers, students and citizen science organisers.
Recruiting Schools	• contacted teachers and school leadership using my professional network and snowball sampling methods about participating in my research	A potential list of five local and eight international schools showed interest to participate in my study
Pilot Study (Phase 1 - May 2020)	• tested pre-survey questions for comprehension, language translation accuracy, timing and validity • involved 87 students in grades 6 to 12 from one international school	An updated set of pre-survey questions, corrected with simpler language in questions and aspects of a Likert scale.
Pilot Study (Phase 2 - Sep-Oct 2020)	• created a small citizen science experience, "Seek Nature HK" to test pre-survey and post-survey reliability, and interview question quality	An updated set of interview questions embedded with online interactive activities for the semi-structured interview. Needed another pilot for testing pre and post-survey reliability as only one student participated in this Phase 2 pilot.
Pilot Study (Phase 3 - Nov 2020)	• tested updated pre-survey and post-survey, and interview questions • involved 19 students in grades 11 to 12 from one school (with a mixture of local and international students)	Survey and interview questions were suitable, as was the Google Slides workspace to conduct interactive elements during the semi-structured interviews. With no change to the instruments, I joined this school's data with my main study's data.
Main Study	• confirmed involvement of three local and five international schools; either contributory or co-created citizen science activities	Received 187 paired student pre and post-surveys, and interviews from 46 students, 18 teachers and four citizen science organisers.
Quantitative Analysis	• identified the 100% completed paired student pre-survey and post-survey data (187 pairs) • cleaned and anonymised the 187 pairs of data • carried out descriptive and inferential statistical analyses using IBM SPSS statistics programme	Analyses revealed various results about changes in values, attitudes, knowledge and behaviours after citizen science experiences, and which variables most influenced pro-environmental

		behaviour, as explained in the next chapter.
Qualitative Analysis	• transcribed all the student, teacher and citizen science organiser interviews (about 280,000 words) • used reflexive thematic analysis approach to determine and organise codes • used QSR's NVivo 20 for Mac programme to create and organise codes, for further thematic analysis	Identified various themes and sub-themes for teacher, student and citizen science organiser interview data, represented in thematic maps in the following results chapters.

Table 15: Chronologic sequence of my approach to data collection and analysis.

CHAPTER 5

5 Results: Impact of Citizen Science Experiences on Student Pro-environmental Values, Attitudes, Knowledge and Behaviours

This is the first of three results chapters about the impact of school-based citizen science on secondary school youth in Hong Kong. Each chapter focuses on a different sub-question, drawing from the relevant quantitative and qualitative data from the pre- and post-surveys, field observations and interviews. Each results chapter closes with a summary of the most important findings. The discussion chapter, Chapter 8 is where the notable findings are brought together and considered within the fields of experiential education, environmental education, citizen science, environmental behaviour psychology, activism and citizenship education.

In this chapter I will demonstrate that citizen science experiences have an effect on environmental values, attitudes, knowledge and behaviours. The chapter begins with an overall description of the citizen science projects the schools in my study engaged in. Then I provide a summary of characteristics of survey participants (students) and interview participants (students, teachers and citizen science organisers). These are featured at this point in the chapter to link the subsequent analyses more clearly, when considering, for example, how impact of citizen science may have differed for participants from different school types. The bulk of this chapter relates to the impact of citizen science experiences and are reported using the following characteristics: all participants, school type, citizen science project type, school level and gender.

The next subsection considers the relationships between the variables that lead to pro-environmental behaviours, based on the environmental behaviour framework (see Figure 8), and how these change after citizen science experiences. I synthesise the overall impacts in the chapter summary, where I contextualise the results amidst some critical evaluation of how much these reported changes are a result of the participant's citizen science experiences at school. These findings are considered amidst related literature about citizen science impact and in conjunction with the findings shared in next two results chapters, in the Discussion, Chapter 8.

5.1 Citizen Science Projects in My Study

Based on specific curricular needs and opportunities afforded during prevailing Covid-19 restrictions between November 2020 to July 2021, eight schools in my study chose to engage in environmental citizen science experiences of varying project type, topic and duration (see Table 16).

School	Curriculum Type	Number of Students (S = survey; I = interviews)	Number of Teachers interviewed	Prior Citizen Science Experience of Teachers	Citizen Science Project Type and Topic	Citizen Science Experience Duration
1	international	S = 15; I = 18	3	no	contributory: terrestrial biodiversity	1 day only: <40 minutes
2	international	S = 134; I = 9	4	some	contributory: terrestrial & coastal biodiversity	1 day only: >40 minutes
3	local	S = 6; I = 5	1	no	contributory: terrestrial biodiversity	1 day only: >40 minutes
4	local	S = 8; I = 1	4	some	contributory: terrestrial biodiversity	1 day only: <40 minutes
5	international	S = 6; I = 1	2	no	contributory: terrestrial biodiversity	1 day only: <40 minutes
6	international	S = 5; I = 2	2	no	co-created: coastal biodiversity & marine pollution	2 days only: >40 minutes
7	international	S = 5; I = 3	1	some	Contributory (online only): air quality	every week/month: >40 minutes
8	local	S = 8; I = 7	1	no	co-created: marine plastic pollution	every week/month: >40 minutes

Table 16: The characteristics of the eight schools that participated in my study during the 2020-2021 academic year. Note that 40 minutes is equal to 1 class period for most schools during the 2020-2021 school year (adapted for the prevailing Covid-19 restrictions, otherwise usually each class period is at least 60 minutes). The colours of the project type and topic refer to the five different citizen science projects that were experienced, see Table 15 for further project descriptions.

Schools 1 to 5 (see Table 16 and the green circles on Figure 10) chose to get involved in the biodiversity citizen science projects during November 2020, with Schools 1, 3 and 5 having had no prior citizen science experience. Schools 6 and 8 engaged in co-created citizen science projects with the support of outside organisations, as they had no prior experience participating in or designing citizen science projects. School 7, which had some experience of citizen science projects, had their students participate in an online-only contributory citizen science project about air quality. Table 17 summarises each of the citizen science projects that the various schools participated in during my study.

Project Type	Project Topic	Project Details
Contributory	Terrestrial biodiversity	Using the 'Seek by iNaturalist' app, one school explored their campus biodiversity under the citizen science project called 'Seek Nature HK'. The 'Seek Nature HK' project was a small project I created to pilot my methodological instruments (survey and interview questions) with students. With Covid-19 restrictions, only one student fully completed all parts of the data collection, so I recruited 19 students from an international school, comprising Hong Kong-based local and international school students and foreign students, to join the project to observe terrestrial biodiversity on their school campus, and participate in my research study.
	Terrestrial and / or marine biodiversity	Using the 'iNaturalist' app and/or website, four schools explored their campus or neighbourhood biodiversity under the citizen science campaign entitled 'Hong Kong Inter School City Nature Challenge' (HKISCNC). The HKISCNC was created to complement the growing interest generated in observing local flora and fauna during annual global City Nature Challenge every April, where Hong Kong ranked in the top 4 cities for total species observed, since joining in 2018 (Collective Results, 2022). During my study, there were 43 local and international schools that participated in the November 2020 HKISCNC across Hong Kong.
	Air quality	This online-only citizen science project on the Zooniverse website platform is entitled 'Project RISE: Recognizing Industrial Smoke Emissions'. The project aims to use people to differentiate between photos of industrial smoke and steam to improve the artificial intelligence algorithm to automatically evaluate air quality in an area. Engaging in this citizen science project and the topic of air quality was part of an afterschool science programme of one school that used a 'Big History' lens to explore the intersection of science and society. To strengthen the connection between Project RISE and the students' own experience of variable air quality in Hong Kong, the original intention was to get involved in an experiential air quality project using mobile sensors, however, Covid-19 restrictions meant no off-campus excursions.
Co-created	Marine biodiversity and pollution	This project was used to support one international school's A-Level geography field investigation looking into relationships between biodiversity and pollution. An environmental NGO supported the school teacher in developing the parameters of the project adapted from one of their own citizen science projects about coastal ecology and debris. This co-created project involved two groups of students and their teachers working over two consecutive days (about 4 hours each time) in two different coastal locations in western Hong Kong. The data was used by students for their geographical investigation and the NGO for their baseline data about the ecological state of Hong Kong's coastlines.
	Marine plastic pollution	A local school's afterschool science interest group enlisted the help of an environmental start-up company to develop a co-created citizen science project investigating the scope of plastic drink bottle pollution on Hong Kong coastlines. This was in support of their overall project to address plastic pollution as part of a global science competition. Students took drone photography of polluted shorelines, and developed and refined the artificial intelligence (AI) algorithms to automatically identify plastic bottles in those photos. This involved a wider group of students identifying plastic bottles in the drone photographs to improve the accuracy of the AI algorithm. The project output led to a multi-pronged approach to address plastic pollution including awareness raising using the citizen science project data about the scope of marine plastic pollution in Hong Kong, and helped to improve the AI algorithm of the environmental start-up company too.

Table 17: A summary of the five different citizen science projects that schools in my study engaged in.

5.2 Characteristics of Survey Participants: Local and International Secondary School Students in Hong Kong

The eight schools were spread across Hong Kong Island, Kowloon and the New Territories in the Special Administrative Region of Hong Kong (see Figs. 9 and 10). Three schools deliver the Hong Kong Diploma of Secondary Education (HKDSE) curriculum and are referred to as 'local schools'. The remaining five schools deliver international curricula, offering the International Baccalaureate (IB), the English (GCSE, IGCSE and A-Levels) or school-specific accredited curricula, and they are collectively referred to as 'international schools'.

The median residency length in Hong Kong for both local and international school students in this study is the same, at 10 - 12 years (see Figure 13). Independent samples T-test results show the difference in means (local school students = 4.32 and international school students = 3.80) as not statistically significant (p = 0.091; t = 1.701). This is highlighted to counter the perceptions that international schools may have more transient non-local student populations (TopSchoolsHK, 2021) compared with local school students, and international school students may not have as much local knowledge because of living in Hong Kong for a shorter period of time.

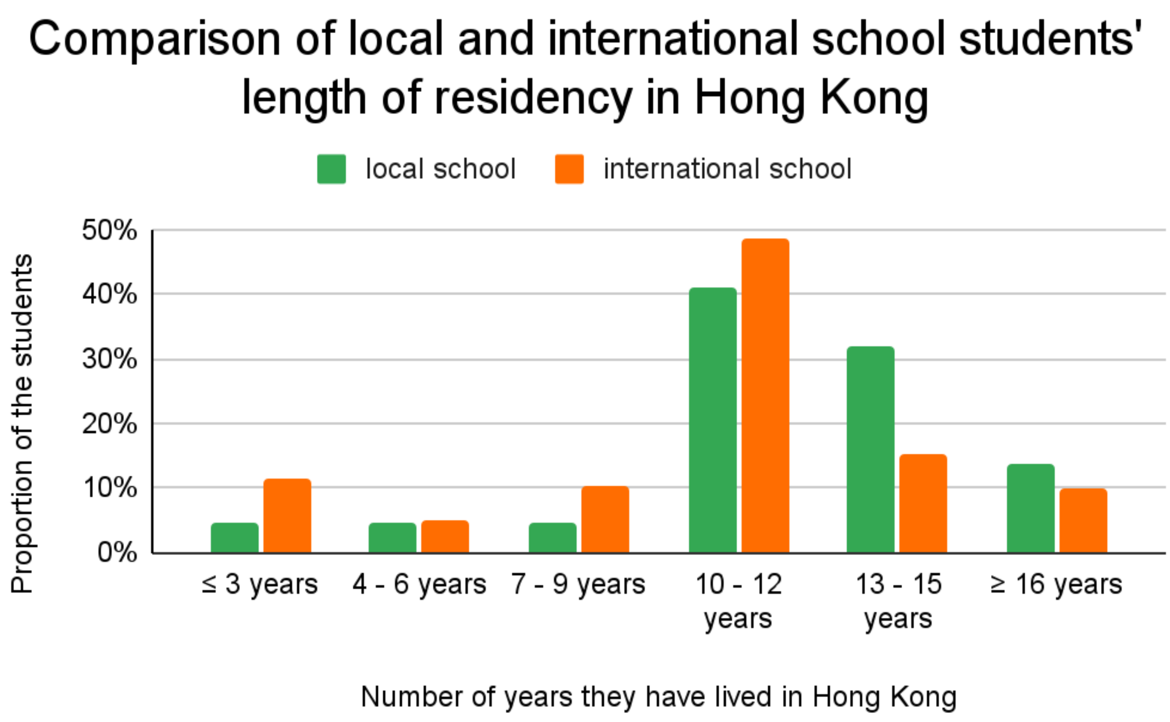


Figure 13: The residency length of local and international school students follows a similar pattern, with most students having lived in Hong Kong for equivalent periods of time (except for the 13-15 year range).

Students in the eight schools completed a pre-survey (T1) and a post-survey (T2) generally about one to two weeks before and after their citizen science experiences, though Covid-19 and school holidays and exams delayed some post-survey responses for some schools. While 421 students fully completed the pre-survey, there was a 55.6% attrition rate between the two surveys, and I obtained complete paired pre-survey and post-survey responses from 187 students. The analyses presented in these results chapters are based on these completed surveys (n = 187).

An analysis of students who submitted incomplete post-surveys showed that 14.8% of them came from local schools and 85.2% from international schools. These proportions are similar to the unequal distribution of the 187 complete paired responses across the eight schools, with a skew towards the international schools at 88.3%, and towards the lower secondary level, namely Grades 6 (Primary 6/P6) and 7 (Form 1/F1) as shown in the bar graph (see Figure 14).

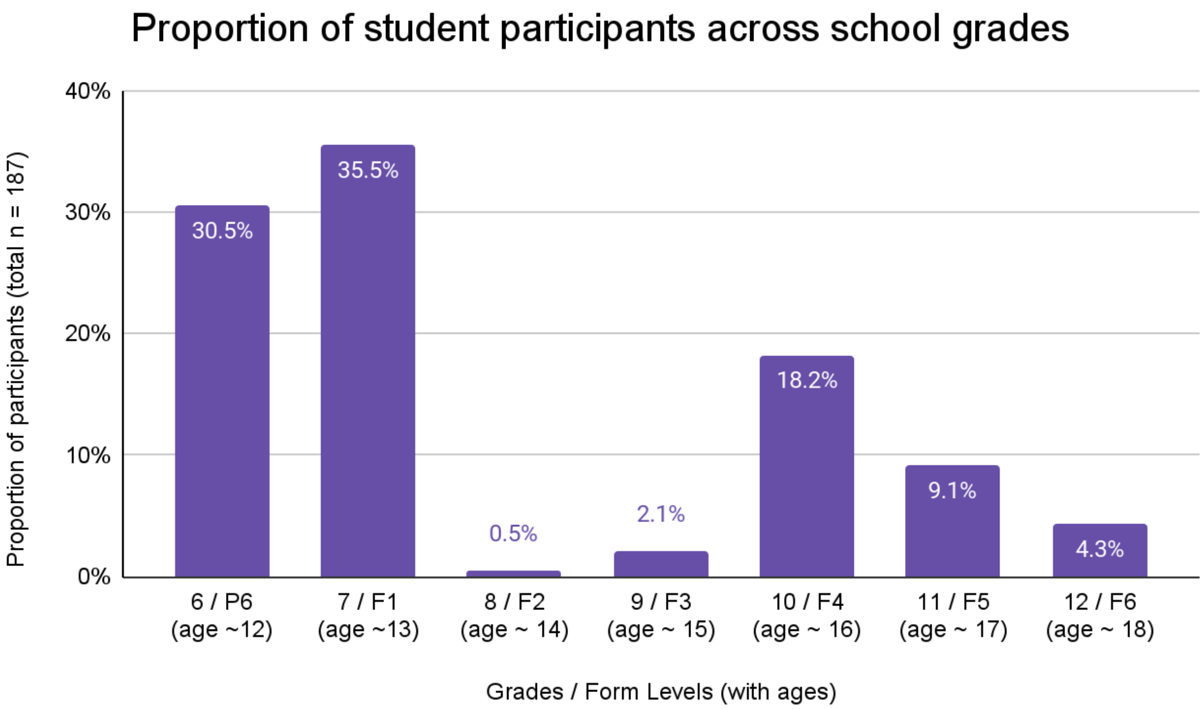


Figure 14: Of 187 paired responses, two-thirds came from Grades 6 / P6 and 7 / F1 (lower secondary levels).

The unevenness in participation across grades is due to teacher-determined opportunities to embed citizen science activities as part of their formal curriculum or as informal after-school sessions during the school year.

Across the eight schools, there were slightly more male students (50.8%) than female students (41.7%) overall and in Grades 6 / P6, 7 / F1, 10 / F4 and 11 / F5 (see Table 18). Students who identified as 'other' or preferred not to say were from Grades 6 / P6 and 7 / F1, and made up 7.5% of the total (14 out of 187 participants).

	6 / P6 (~12y.o)	7 / F1 (~13y.o)	8 / F2 (~14y.o)	9 / F3 (~15y.o)	10 / F4 (~16y.o)	11 / F5 (~17y.o)	12 / F6 (~18y.o)	Total
Female	24	24	-	-	16	8	6	78
Male	29	32	1	4	18	9	2	95
Other	3	8	-	-	-	-	-	11
Prefer not to say	1	2	-	-	-	-	-	3
Total # of students	57	66	1	4	34	17	8	187

Table 18: The number of students who identified either as female, male, preferred not to say or other, per grade.

Most students (59.9%) had no experience with citizen science prior to the study, though one local and two international schools had engaged in informal learning opportunities using biodiversity and air quality monitoring citizen science projects prior to the 2020-2021 academic year.

Despite 40.1% of the students having at least one prior citizen science experience, it made no difference to their accuracy in defining the term 'citizen science'. Applying the codebook created by Kudumu et al. (2021) to evaluate the 3-component ('public', 'scientist' and 'scientific process') definition of citizen science, 44% of students with prior citizen science experience scored 0 out of 3, the same result for 41.1% of students with no prior experience. The mean accuracy for those with no experience was 1 out of 3, slightly more than 0.97 out of 3 for students with some citizen science experience, though the difference is not statistically significant using the Independent Samples Median test ($x^2 = 0.025$, $p = .875$, n = 187). Overall, most students scored either 0 or 1 out of 3 (see Figure 15), with only 40.1% and 0.5% getting 2 or 3 out of 3 correct, respectively. Often the missing element from their descriptions was the component of working in collaboration with a scientist or expert, with a common example being "its science for nonprofessional scientist, it’s for normal citizens like me". The only fully accurate response (3 out of 3) was by a 7th grade student with no prior citizen science experience, stating that citizen science comprises "projects that citizens/the public can also participate in to generate data that helps scientists' discoveries." These results reveal some limited and variable levels of prior understanding about the dimensions of citizen science, and may play some part in explaining the student perceptions of their citizen science experiences during their interviews.

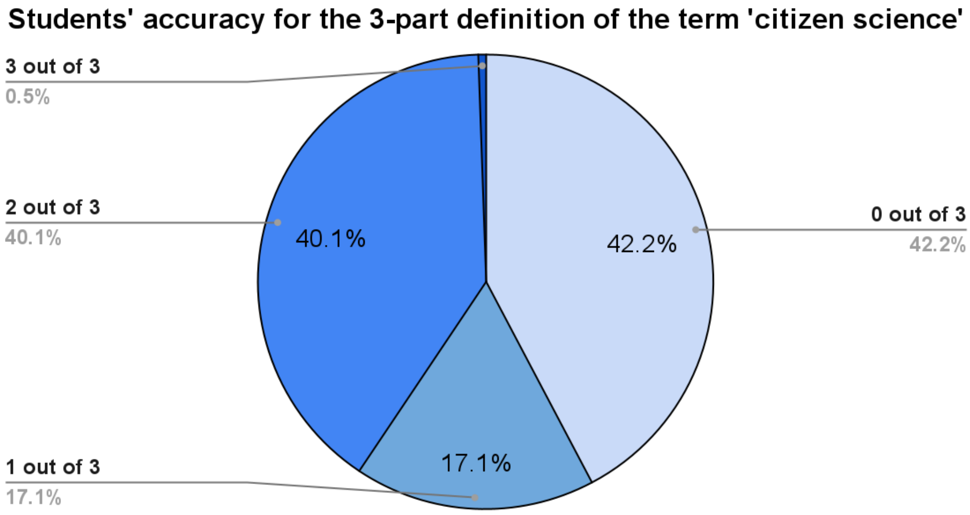


Figure 15: A pie-chart showing that the majority (59.3%) of the students scored 0 or 1 of the 3 potential elements in the citizen science definition, using the codebook by Kudumu et al., (2021). Note at the top of the pie-chart that only 0.5% of students (1 student out of 187 students) responded with a complete definition that included the 'public', 'scientist' and 'scientific process' elements of the definition and scored 3 out of 3.

A Pearson's correlation test shows a strong negative relationship (R^2 = -.921, p = .009, n = 6) between grade level and the proportion of students with complete inaccuracy for the definition of citizen science (0 out of 3 correct; see Fig. 15). Almost 60% of Grade 6 students scored 0 out of 3, compared to around 15% of Grade 12 students, suggesting that there is a greater capacity of older students using general understanding of the words 'citizen' and 'science' to at least unpack what the phrase might mean.

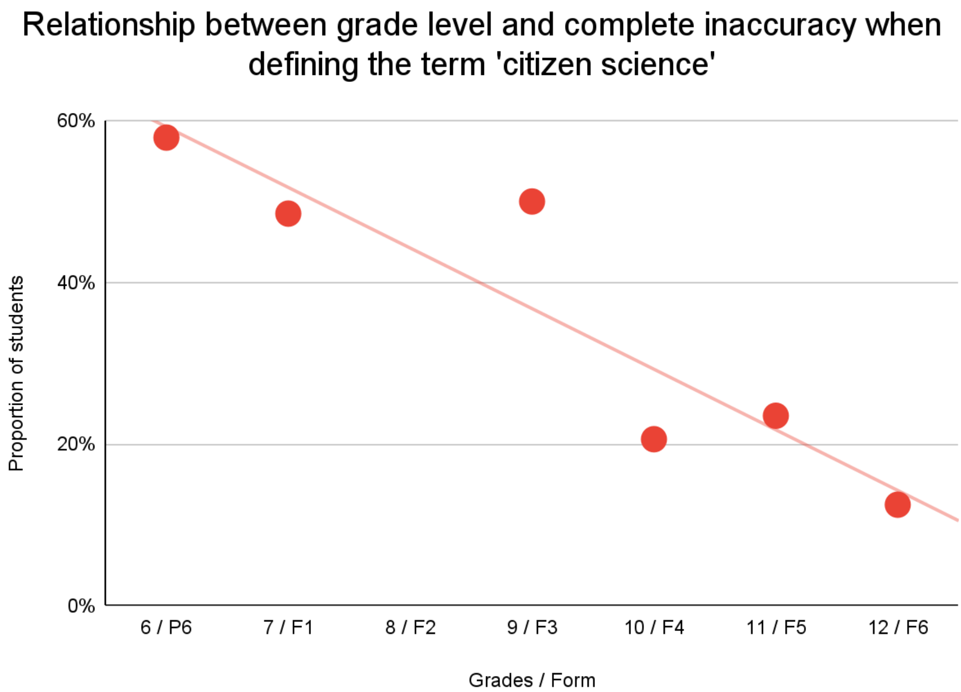


Figure 16: A scatterplot showing a negative correlation (R^2= -.921, p = 0.009) between grade level and proportion of students with completely inaccurate responses to the definition of citizen science (getting 0 out of 3).

5.3 Characteristics of Interview participants: Teachers, Students and Citizen Science Organisers

5.3.1 Teachers

There were 18 teachers who were interviewed, with 78% (n = 14) having an expertise in teaching the sciences (see Table 19). There were six local school teachers and twelve international school teachers interviewed, which is a similar proportion of a minority representation from the local schools for student interviewees as well. Contrary to the slight male skew in gender for students, 61% of teachers interviewed were female (n = 11). Fifty percent of the teachers (n = 9) had no prior experience with citizen science (see Table 16). Three teachers from a local and an international school with no prior experience chose to embed a co-created citizen science experience as part of their informal afterschool science club (local school) and their formal geography curriculum (international school).

Teacher	School	School Type	Gender	Teaching specialty
1	1	International	F	English
2			F	French
3			M	Science
4	2	International	F	Science
5			F	Science
6			F	Science
7			M	Science
8	3	Local	F	Science
9	4	Local	M	Science
10			M	Science
11			F	Science
12			M	Science
13	5	International	F	Science
14			F	Science
15	6	International	M	Geography
16			M	Geography
17	7	International	F	Science/Humanities
18	8	Local	F	Science

Table 19: A summary of characteristics of interviewed teachers across the eight participating schools.

The following table (see Table 20) is the quote attribution key used after each teacher quote in the following chapters to reveal which type of school they worked at, what type of citizen science project they were involved in, and what main subjects they taught, while maintaining anonymity. I monitored my use of quotes with a quote tracker table (see Appendix F) to ensure I represented participant perspectives as broadly as possible, and for teachers, I used at least one quote from every teacher I interviewed.

<table>
<tr><th colspan="4">Teacher Quote Attributes</th></tr>
<tr><td>School Type</td><td>LS = Local School</td><td colspan="2">IS = International School</td></tr>
<tr><td>Citizen Science Project Type</td><td>C = Contributory Citizen Science</td><td colspan="2">Co = Co-created Citizen Science</td></tr>
<tr><td>Subject Taught</td><td>Geo = Geography</td><td>Lang = Languages</td><td>Sci = Science</td></tr>
</table>

Table 20: Teacher quote attribution key

5.3.2 Students

Seventeen female and 29 male students (n = 46) opted to participate in semi-structured interviews. Seventy percent of the 46 students had fully responded in both the pre-survey and post-surveys. The remaining 30% completed either the pre-survey, the post-survey, or did neither of them. Student interviews skewed towards more international school students; 71.7% were international school students versus 28.3% from local schools. A skew was expected because more international schools participated (five international schools versus three local schools) and likely because of local school students' confidence in English communication, despite providing options to respond in written (traditional and simplified Chinese characters) or orally in Cantonese and Mandarin (see Table 16).

The students interviewed (n = 46) seem to be fairly representative of the larger sample of 187 students who had completed the pre and post-surveys, by prior citizen science experience, school type and gender (see Table 21). The interviewed students were from the full range of schools (n = 8), across all grades (Grades 6 - 12) and citizen science project type (contributory and co-created projects). Of the interviewees who completed the pre and post-surveys (n = 32), 59.4% had never engaged in a citizen science project before the study, which is very similar to the full surveyed population (n = 187) of 59.9% without prior citizen science experience.

School	Type	Number of Students Interviewed	Grades Levels Represented
1	international	18	11 and 12
2	international	9	6, 8, and 10
3	local	5	7
4	local	1	7
5	international	1	6
6	international	2	11
7	international	3	7
8	local	7	9, 10 and 11

Table 21: A summary of characteristics of students who opted in for interviews (n = 46). Note the skew that only 28.3% of the interviewees attended local schools, and that two schools only have one interviewee each.

Their accuracy when defining citizen science also followed a similar pattern compared with the total surveyed group of students (see Figure 17, compared with Figure 15), with only a minority (34.4%) scoring 2 out of 3, and in this group, no student had 100% accuracy. Most interviewed students, 65.6% (n = 30), scored either 0 or 1 out of the possible 3.

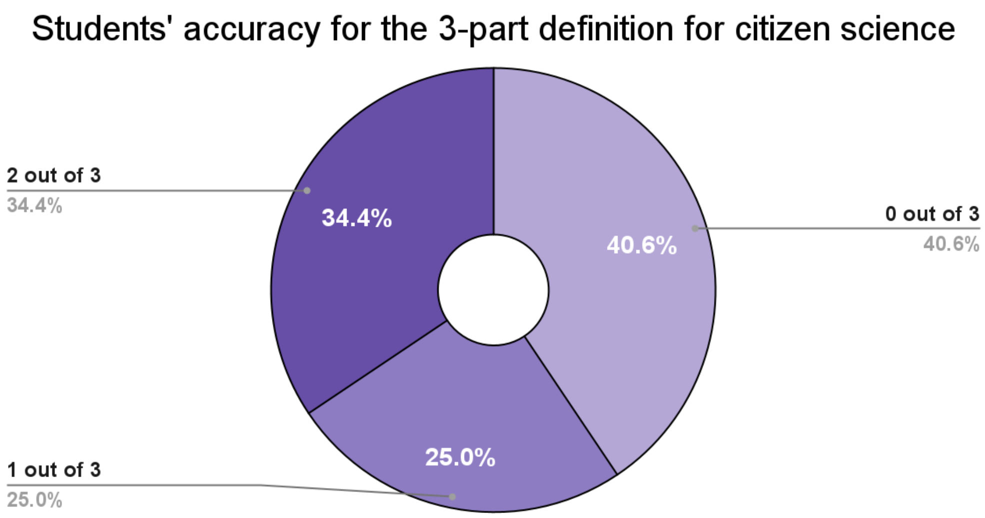


Figure 17: The interviewed students had a similar trend for their accuracy with the citizen science definition, with about two-thirds of them identifying none or only 1 out of the 3 components.

One aspect that differs from the overall student population in the study is the residency times of the students who were interviewed. Though there is a slight skew to longer residency times with the median range being between 10 and 15 years, 25% of those interviewed had lived in Hong Kong between less than a year up to 9 years (see Figure 18).

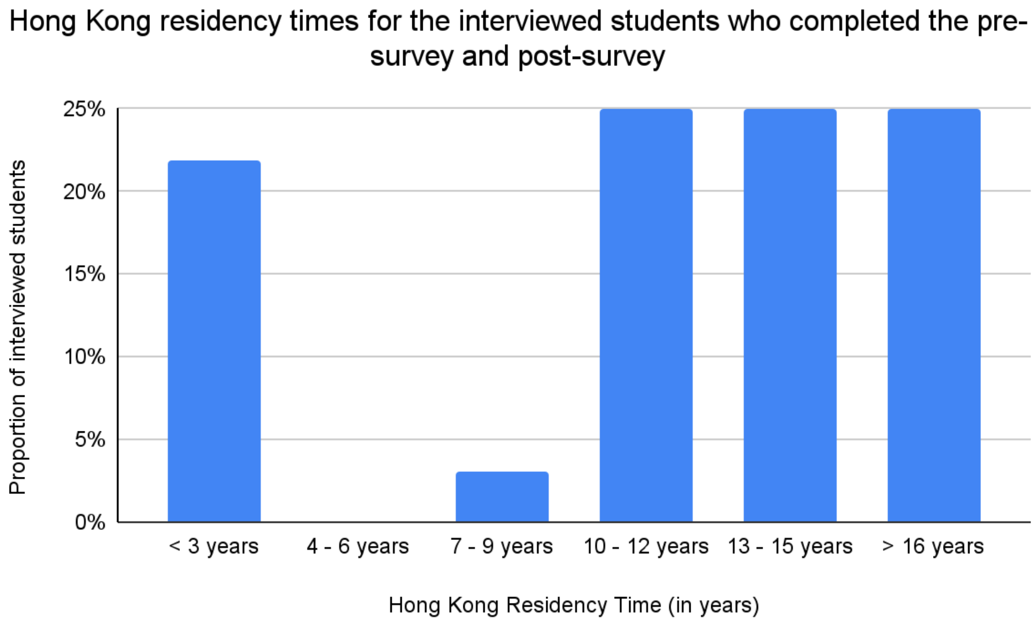


Figure 18: The range of residency times (in years) of interviewed students who completed both surveys (n = 32).

Table 22 is the quote attribution key used after each student quote in the following chapters to reveal which type of school they attended, what type of citizen science project they were involved in, their school level and their gender while maintaining anonymity. I monitored my use of quotes with a quote tracker table (see Appendix F) to ensure I represented participant perspectives as broadly as possible, and for students, I used at least one quote from 38 out of the 46 students I interviewed.

Student Quote Attributes		
School Type	LS = Local School	IS = International School
Citizen Science Project Type	C = Contributory Citizen Science	Co = Co-created Citizen Science
School Level	YS = Younger Secondary (Gr. 6-8)	OS = Older Secondary (Gr. 9-12)
Gender	F = Female	M = Male

Table 22: Student quote attribution key.

5.3.3 Citizen Science Organisers

There were four citizen science organisers that were interviewed in individual semi-structured interviews. Two were associated with the Hong Kong Inter School City Nature Challenge (HKISCNC), the contributory citizen science project that most schools participated in. One organiser worked at an environmental NGO and supported a co-created citizen science project with a school to investigate coastal ecology and pollution. The other organiser was the founder of an environmental start-up and supported a local school with AI technicality for assessing marine plastic pollution in a different co-created citizen science project.

One of the organisers had prior experience working with students as a school teacher, before turning to a career with an environmental NGO. One of the HKISCNC organisers was a volunteer with the NGO because of interest in environmental issues, however, otherwise, they did not work in that realm. The remaining organisers, who were involved in co-created citizen science projects, have always worked in the environmental field since graduating from university with environmentally-related degrees.

Subsections 5.1 and 5.2 provided context about survey and interview participants. The following subsections focus on reporting the scope of the changes seen between the pre and post-surveys, supplemented by interview findings.

The following table (see Table 23) is the quote attribution key used after each citizen science organiser quote in the following chapters to reveal what type of organisation they were a part of and what type of citizen science project they had developed, while maintaining anonymity. I monitored my use of quotes with a quote tracker table (see Appendix F) to ensure I represented participant perspectives as broadly as possible, and for organisers, I used at least five quotes from every organiser I interviewed.

Citizen Science Organiser Quote Attributes		
Organisation Type	NGO = Environmental Non-Governmental Organisation	S-U = Environmental Start-up Company
Citizen Science Project Type	C = Contributory Citizen Science	Co = Co-created Citizen Science

Table 23: Citizen science organiser quote attribution key.

5.4 Citizen science impacts on students' values, attitudes, knowledge and behaviours

This subsection analyses the impact of citizen science experiences on students using related samples Wilcoxon signed rank tests of pre and post-survey data. These tests to measure difference considered change in 14 variables of the Environmental Behavioural Framework (see Table 24).

Values	Attitudes	Experiences	Knowledge	Behaviours
Preservation	Intrinsic Motivation	Personal	Local	Behavioural Intention
Utilization	Social Influence	Household	Global	Self-reported Behaviours
	Response Efficacy		Total	
	Importance of Self-efficacy Skills			
	Confidence in Self-efficacy Skills			

Table 24: Variables analysed for change, between surveys, with the related samples Wilcoxon signed rank tests.

The findings are organised by five characteristics: overall data (5.4.1), school type (5.4.2), citizen science project type (5.4.3), school level (5.4.4) and gender (5.4.5). Tables summarise the pre-survey and post-survey changes for all 14 variables of the Environmental Behavioural Framework with the five characteristics from related samples Wilcoxon signed rank tests, using symbols (see Table 25) and with the statistical detail (see Table 26). The complete results table of statistical results comprising pre-survey means (M_{T1}), post-survey means (M_{T2}), Wilcoxon test statistics (W), *p*-values for statistical significance (*p*), effect size (r), sample size (n) and the probability of superiority statistic (PS value). It should be noted that 'total knowledge' is a combination of the 'local knowledge' questions (4 items) and the 'global knowledge' questions (2 items). Thus, often when 'local knowledge' change is reported, it is also reflected in 'total knowledge'. Where appropriate, qualitative evidence from interviews is weaved through the following subsections to add depth as I explain the quantitative findings.

		Vales		Attitudes					Experiences		Knowledge			Behaviours	
		Preservation	Utilization	Intrinsic Motivation	Social Influence	Response Efficacy	Self-efficacy Importance	Self-efficacy Confidence	Personal	Household	Local	Global	Total	Behavioural Intention	Self-reported Behaviours
Overall		**--**	+	+	+	+	--	**--**	+	+	**+**	+	**+**	+	**+**
School Type	Local Schools	+	+	+	--	--	*no change*	+	--	--	**+**	--	+	+	+
	International Schools	**--**	+	+	+	+	--	**--**	+	--	**+**	+	**+**	+	**+**
Citizen Science Project Type	Contributory Projects	**--**	+	+	+	+	--	**--**	+	+	**+**	+	**+**	+	**+**
	Co-created Projects	**--**	+	*no change*	--	+	**--**	+	+	--	**+**	+	**+**	+	**+**
School Level	Younger Secondary (Gr. 6-8)	--	+	--	--	+	+	--	+	--	**+**	+	+	+	+
	Older Secondary (Gr. 9-12)	**--**	+	+	+	+	--	--	+	--	**+**	+	**+**	--	**+**
Gender	Female	**--**	+	+	+	+	--	**--**	+	--	**+**	+	**+**	+	+
	Male	--	--	--	--	--	--	--	+	--	**+**	+	**+**	+	**+**
	Other	--	+	--	--	+	+	+	+	*no change*	*no change*	*no change*	*no change*	+	--
	Prefer not to say	--	+	+	--	--	--	--	--	+	--	+	--	+	+

Table 25: Graphic table showing positive, negative or no change after citizen science experiences, as measured by related pairs Wilcoxon signed rank tests. Signs in bold are statistically significant ($p < .05$); a negative (--) sign shows a decrease (with orange highlight), and a positive (+) sign shows an increase (with green highlight).

Mean (T1) Mean (T2) Test statistic (*W*) *p*-value Effect size (*r*) PS value	each cell comprises up to these pieces of information	Vales		Attitudes					Experiences		Knowledge			Behaviours	
		Preservation	Utilization	Intrinsic Motivation	Social Influence	Response Efficacy	Self-efficacy Importance	Self-efficacy Confidence	Personal	Household	Local	Global	Total	Behavioural Intention	Self-reported Behaviours
Overall (n = 187)		19.91 19.50 4061 .013 0.181 60	11.50 11.84 5584 .298 (not statistically significant)	7.40 7.47 2587.50 .637 (not statistically significant)	11.56 11.58 4693 .942 (not statistically significant)	7.43 7.49 3105.50 .416 (not statistically significant)	21.23 21.00 4046.50 .356 (not statistically significant)	19.19 18.54 4386 .022 0.167 59	12.34 12.43 5835 .809 (not statistically significant)	21.94 21.87 6038.50 .991 (not statistically significant)	1.35 1.62 4638 <.001 0.246 64	0.93 0.98 1013.50 .285 (not statistically significant)	2.27 2.60 5601 <.001 0.248 64	17.36 17.54 5560.5 .460 (not statistically significant)	27.60 28.70 9053.50 .003 0.215 62
School Type	**Local Schools** (n = 22)	19.91 20.45 54 .726 (not statistically significant)	12.45 12.77 76 .677 (not statistically significant)	7.41 7.64 29.50 .444 (not statistically significant)	12.18 11.82 43.50 .340 (not statistically significant)	8.05 8.00 33 1.000 (not statistically significant)	21.27 21.27 36 .505 (not statistically significant)	19.55 20.14 40 .253 (not statistically significant)	10.55 10.27 64 .552 (not statistically significant)	21.50 21.27 61 .715 (not statistically significant)	2.57 2.93 22 .05 0.418 74	1.00 0.95 9 .739 (not statistically significant)	3.57 3.89 47 .152 (not statistically significant)	17.59 18.09 40.50 .263 (not statistically significant)	27.82 28.00 78.50 .197 (not statistically significant)
	International Schools (n = 165)	19.91 19.37 3190 .012 0.196 61	11.37 11.72 3504.50 .352 (not statistically significant)	7.39 7.45 2082.50 .823 (not statistically significant)	11.48 11.55 3669.50 .832 (not statistically significant)	7.35 7.42 2524 .396 (not statistically significant)	21.22 20.96 3335 .438 (not statistically significant)	19.10 18.30 3285 .006 0.215 62	12.58 12.72 4483.50 .598 (not statistically significant)	22.60 21.95 4793.50 0.880 (not statistically significant)	1.18 1.45 1830.50 .004 0.227 63	0.92 0.98 815 .214 (not statistically significant)	2.10 2.43 2092.50 .001 0.248 62	17.33 17.47 4643.50 .639 (not statistically significant)	27.5 28.8 4080.50 .006 0.214 62
Citizen Science Project Type	**Contributory Projects** (n = 174)	19.84 19.45 3769 .037 0.196 61	11.50 11.84 3941 .305 (not statistically significant)	7.36 7.44 2203 .641 (not statistically significant)	11.52 11.57 4131 .884 (not statistically significant)	7.45 7.49 2870 .576 (not statistically significant)	21.16 21.05 3828.50 .674 (not statistically significant)	19.23 18.53 3757 .019 0.197 61	12.48 12.56 5168 .917 (not statistically significant)	21.95 21.98 4886 .595 (not statistically significant)	1.26 1.53 1990 .002 0.164 59	0.89 0.94 935 .325 (not statistically significant)	2.15 2.46 2424 .002 0.167 59	17.33 17.52 5066.5 .468 (not statistically significant)	27.64 28.67 4762.50 .012 0.135 57
	Co-created Projects (n = 13)	20.85 20.08 2.50 .026 0.436 75	11.46 11.77 27 .959 (not statistically significant)	7.85 7.85 17.50 .943 (not statistically significant)	12.08 11.62 7 .107 (not statistically significant)	7.15 7.54 5 .236 (not statistically significant)	22.15 20.31 2 .042 0.399 73	18.62 18.69 27 .959 (not statistically significant)	10.38 10.69 22 .572 (not statistically significant)	21.77 20.38 15 .058 (not statistically significant)	2.46 2.89 6 .046 0.391 73	1.46 1.54 2 .564 (not statistically significant)	3.92 4.42 6 .025 0.438 75	17.77 17.85 13 .863 (not statistically significant)	26.38 28.77 9.50 .02 0.455 76
School Level	**Younger Secondary** (Gr. 6-8; n = 124)	19.44 19.13 2124 .214 (not statistically significant)	11.98 12.01 2211 .797 (not statistically significant)	7.37 7.35 1018.50 .884 (not statistically significant)	11.52 11.48 1887.50 .910 (not statistically significant)	7.51 7.56 1348 .542 (not statistically significant)	20.81 20.82 1908.50 .981 (not statistically significant)	19.19 18.57 1970 .105 (not statistically significant)	12.94 12.98 2567.50 .978 (not statistically significant)	22.27 22.17 2539.50 .902 (not statistically significant)	1.25 1.46 1134 .048 0.126 57	0.78 0.81 520 .609 (not statistically significant)	2.04 2.27 1411.50 .061 (not statistically significant)	17.29 17.61 2432.50 .331 (not statistically significant)	28.23 28.58 3498.50 .331 (not statistically significant)
	Older Secondary (Gr. 9-12; n = 63)	20.83 20.22 293 .006 0.246 64	10.73 11.51 425 .137 (not statistically significant)	7.44 7.71 342 .348 (not statistically significant)	11.65 11.78 634.50 .976 (not statistically significant)	7.29 7.37 369 .568 (not statistically significant)	22.05 21.35 392 .103 (not statistically significant)	19.19 18.48 478 .081 (not statistically significant)	11.16 11.33 669 .677 (not statistically significant)	21.30 21.27 711 .784 (not statistically significant)	1.53 1.94 182 .002 0.278 65	1.21 1.30 85.50 .259 (not statistically significant)	2.74 3.25 202.50 <.001 0.309 67	17.49 17.40 626 .911 (not statistically significant)	26.22 28.86 342 <.001 0.344 69
Gender	**Female** (n = 78)	20.50 19.97 675 .032 0.172 59	10.60 11.41 679.50 .117 (not statistically significant)	7.44 7.67 395 .338 (not statistically significant)	11.55 11.82 561.50 .455 (not statistically significant)	7.33 7.47 499 .243 (not statistically significant)	21.18 21.13 796 .987 (not statistically significant)	19.13 18.12 580.50 .021 0.185 60	12.77 12.88 961 .912 (not statistically significant)	21.99 21.97 1068.50 .979 (not statistically significant)	1.16 1.58 234.50 <.001 0.265 65	0.87 0.91 156 .577 (not statistically significant)	2.03 2.49 313.50 .001 0.255 64	18.17 18.26 943.50 .988 (not statistically significant)	27.90 28.58 1080.50 .257 (not statistically significant)
	Male (n = 95)	19.72 19.41 1060 .146 (not statistically significant)	12.07 12.02 1197.50 .791 (not statistically significant)	7.42 7.34 657 .596 (not statistically significant)	11.54 11.53 1422 .987 (not statistically significant)	7.53 7.52 883 .988 (not statistically significant)	21.34 21.03 996 .370 (not statistically significant)	19.26 19.04 1431 .362 (not statistically significant)	12.13 12.26 1534.50 .680 (not statistically significant)	21.98 21.72 1420 .677 (not statistically significant)	1.53 1.76 737.50 .035 0.153 58	1.00 1.06 299 .389 (not statistically significant)	2.53 2.83 923.50 .038 0.151 58	17.13 17.26 1604.50 .652 (not statistically significant)	27.88 29.38 1308 .010 0.186 59
	Other (n = 3)	15.00 14.67 3 1 (not statistically significant)	11.67 12.33 2.50 .785 (not statistically significant)	8.00 7.00 0 .317 (not statistically significant)	11.00 10.33 1 .655 (not statistically significant)	6.67 7.33 0 .109 (not statistically significant)	18.00 21.33 0 .109 (not statistically significant)	16.67 18.00 0 .180 (not statistically significant)	9.00 10.33 0 .157 (not statistically significant)	20.33 20.33 3 1 (not statistically significant)	1.00 1.00 1.50 1 (not statistically significant)	1.00 1.00 1.50 1 (not statistically significant)	2.00 2.00 1.50 1 (not statistically significant)	12.00 12.33 3 1 (not statistically significant)	20.67 18.67 0 .317 (not statistically significant)
	Prefer not to say (n = 11)	18.45 18.18 14.50 .619 (not statistically significant)	12.82 13.18 20 .427 (not statistically significant)	6.73 7.36 5 .121 (not statistically significant)	12.00 10.64 14 .165 (not statistically significant)	7.55 7.45 13.50 .931 (not statistically significant)	21.55 19.73 2.50 .051 (not statistically significant)	19.64 17.36 11 .324 (not statistically significant)	12.00 11.18 16 .223 (not statistically significant)	21.73 22.82 17 .280 (not statistically significant)	1.18 0.81 3.50 .102 (not statistically significant)	0.64 0.73 2.50 .785 (not statistically significant)	1.82 1.55 6 .317 (not statistically significant)	15.09 16.27 10 .260 (not statistically significant)	24.09 26.00 14.50 .183 (not statistically significant)

Table 26: A table summarizing all the related samples Wilcoxon signed rank tests results comparing pre and post-survey data. For non-statistically significant results, the effect size (r) and PS value were not calculated. Light orange cells show a decrease, while light green cells show an increase after a citizen science experience.

5.4.1 Changes in Total Sample of Surveyed Students

Across the pre and post-surveys from the 187 students, the variables that had statistically significant change after citizen science experiences were (i) preservation values, (ii) confidence in self-efficacy skills, (iii) local knowledge, (iv) total knowledge, and (v) self-reported behaviour. The means for preservation values and confidence in self-efficacy skills decreased after the citizen science experience, while the means for local knowledge, total knowledge and self-reported behaviours increased (see Table 25 and Table 26).

The scatterplots displaying the Preservation and Utilization values before and after the students' citizen science experiences look very similar (see Figure 19 and Figure 20). The majority of students' Preservation values before and after citizen science were at high levels (coloured green in Figure 19 and Figure 20), while Utilization values being represented across the range of low to high levels. There is a slightly higher mean in post-surveys (M_{T2} = 11.84) than the pre-surveys for Utilization values (M_{T1} = 11.50; W = 5584; *p* = .298), though the result is not statistically significant.

There is a small statistically significant decrease (2.1%) in the total preservation value between the pre-survey (M_{T1} = 19.91) and the post-survey (M_{T2} = 19.50; W = 4061, *p* = .013, r = 0.181, PS = 60). The pre and post-survey environmental values scatterplots of preservation and utilization values show most students scored in the upper band (highlighted in light green) of reservation values (see Figure 19 and Figure 20). The effect size for the negative impact of citizen science on preservation values is considered to be low, meaning that while there is a statistically-significant difference, the amount of change is small and has a small effect. This suggests that the magnitude of the decreased effect on preservation values is small. Only one of the five items for preservation value total had a statistically significant influence on the decrease observed: statement P3, "refusing to use single-use plastic items is a useful way to take action about reducing waste". There was no statistically significant change for the other statements, with pre and post-survey means staying mostly the same (see Table 27).

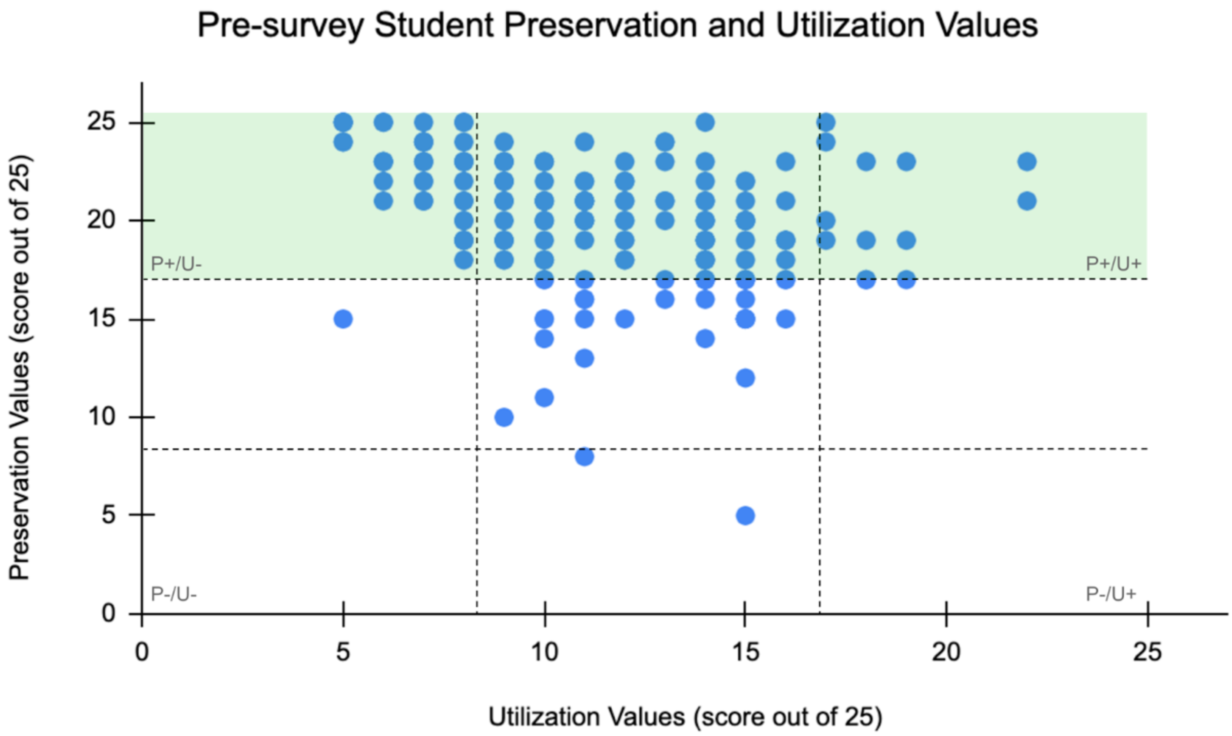


Figure 19: Scatterplots of pre-survey environmental values, with preservation value totals on the y-axis and Utilization value totals (out of 25) on the x-axis. Note the light green band indicating the higher band of preservation values, where most values are, while there is a range of low, moderate and high utilization values in both charts. The chart has been split into thirds (dashed lines) denoting high, moderate and low values for either preservation or utilization values (out of the total possible score of 25).

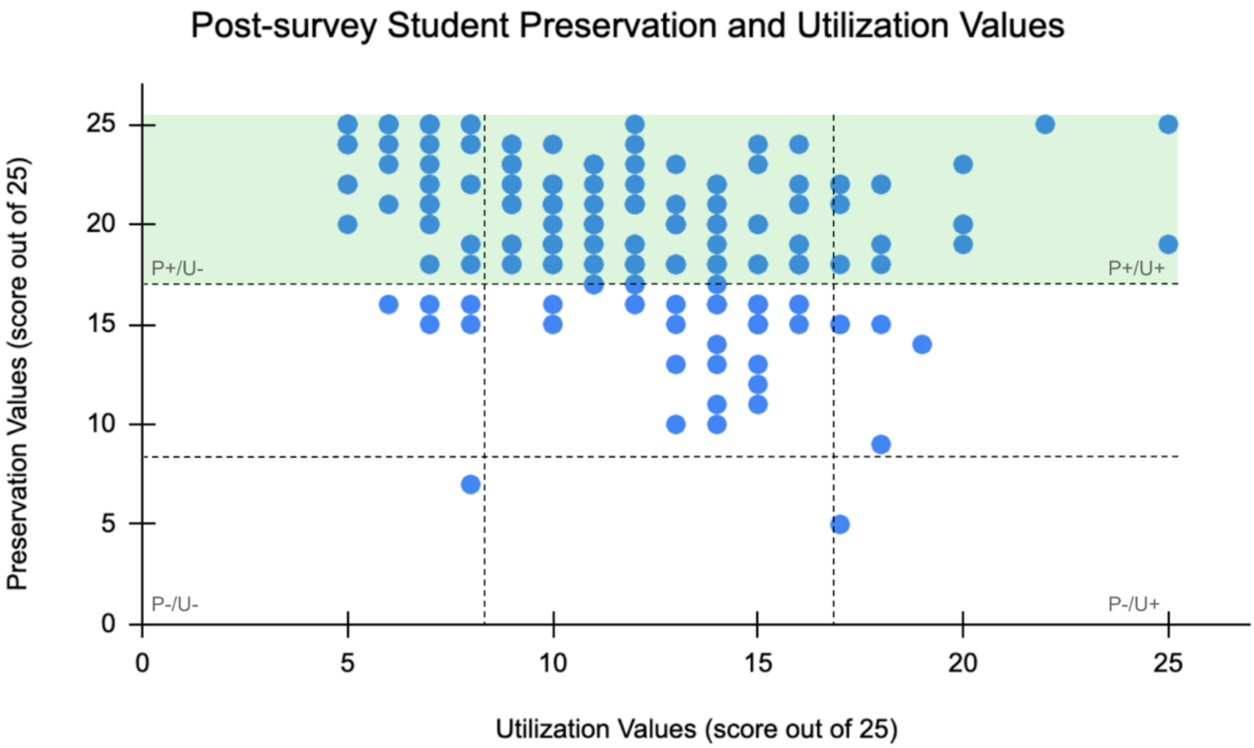


Figure 20: Scatterplots of post-survey environmental values, with preservation value totals on the y-axis and Utilization value totals (out of 25) on the x-axis. Note the light green band indicating the higher band of preservation values, where most values are, while there is a range of low, moderate and high utilization values in both charts. The chart has been split into thirds (dashed lines) denoting high, moderate and low values for either preservation or utilization values (out of the total possible score of 25).

	Preservation Values Statements	**Related Samples Wilcoxon signed rank test statistics**
P1	It is interesting to know which animals and plants exist in my community and the world.	M_{T1} and M_{T2} = 4.1 $p = .451$, $W = 1511.50$
P2	I enjoy being in nature (i.e. parks, countryside, beaches, gardens, forests, hills).	M_{T1} and M_{T2} = 3.9 $p = .756$, $W = 1482$
P3	**Refusing to use single-use plastic items is a useful way to take action about reducing waste.**	**M_{T1} = 4.2 and M_{T2} = 4.0** **$p = .015$, $W = 1438.50$**
P4	My connection to nature is an important part of who I am.	M_{T1} = 3.5 and M_{T2} = 3.4 $p = .232$, $W = 1771$
P5	Cleaning up the environment and protecting endangered species must be done, even if this costs money that could have been spent on supporting other important issues.	M_{T1} and M_{T2} = 4.1 $p = .147$, $W = 1170$

Table 27: The statements that make up the five items to calculate the total for preservation values (out of 25), with the statistically significant item in bold, which influenced the decrease in overall preservation values.

P3 is a statement conveying judgement about the effectiveness of a form of pro-environmental citizenship action and it may speak to one's values about the effectiveness of taking such action considering the scale of the issue, rather than just the action itself. The phrase "is a useful way to take action" in the P3 statement is where the challenge may lie, as most of the students across the interviews expressed uncertainty about the meaningfulness or impact of one's individual actions. A student recalled how during a field trip, they had "been taking pictures of plastics, and the results are absolutely horrifying, I have to say… Like, sandy beach of plastics is like, kind of scary" (LS, Co, OS, M). Another student shared that seeing the scale of anthropogenic environmental damage was "intimidating because you're like, wow, this is getting out of hand" (IS, C, YS, F). Yet another student shared a similar sentiment and questioned the limitation of not addressing the issue at its source, suggesting that one is "fixing the issue that is caused by the issue, but you're not thinking the actual issue itself, yeah, the root cause" (IS, C, OS, M). These perceptions could help to explain how simply refusing plastic items may not go very far to address the waste problem and how students may see the P3 statement as less effective in light of the enormity of the pollution issue after their exposure. These sentiments may also explain the slight decrease in confidence in one's self-efficacy (see Table 24 and Table 25). Self-efficacy is defined as having the belief that one has the skills to successfully take action, so this reported decline may well reflect how exposure to large-scale complex issues during their citizen science experience effects their sense of agency and capacity to make a consequential difference.

Results show that confidence in one's self-efficacy skills decreases after a citizen science experience, but the effect is low. There is a small statistically significant decrease (3.4%) in total confidence of self-efficacy skills from the post-survey (M_{T2} = 18.54) compared with the pre-survey (M_{T1} = 19.19; W = 4386, p = .022, r = 0.167, PS = 59). The pre and post-survey means indicate students generally rated 'somewhat agree' for having confidence in their self-efficacy skills on the 5-point Likert scale for agreement. Students with no prior experience with citizen science activities (n = 112) showed a 4.2% decrease in confidence in their self-efficacy skills (M_{T1} = 19.10; M_{T2} = 18.30; W = 1403.50, p = .02), while there was no statistically significant change for those students who had at least one citizen science experience beforehand (n = 75). While there was this slight decline, students also reported a new appreciation for conducting citizen science fieldwork and upholding research rigor (IS, Co, OS, M):

> *It's made me think about experiments. Obviously, I understand why repeating them is good for reliability. But then I also understand that it's like, although we only sample data from Tai O... if this were to be part of some higher scientific study, collecting data from a range of Hong Kong's beaches, we could compare more geography as well. And then it's also made me think about important steps to making experiments repeatable.*

After a citizen science experience, there were statistically significant increases in the means for local and total knowledge, and the effect was moderate. There were no statistically significant changes to global knowledge, thus the impact on total knowledge is influenced by the changes to local knowledge. There was a 20% increase in local knowledge from the pre-survey (M_{T1} = 1.35) to the post-survey (M_{T2} = 1.62; W = 4638, $p < .001$, r = 0.246, PS = 64), and a 14.5% increase in total knowledge from the pre-survey (M_{T1} = 2.27) to the post-survey (M_{T2} = 2.60; W = 5601, $p < .001$, r = 0.248, PS = 64). These positive changes in local knowledge were also seen regardless of whether a student had prior experience with a citizen science activity or not. Students with no prior experience had increased accuracy in local knowledge by 19% (M_{T1} = 1.287; M_{T2} = 1.573; W = 372.50, p = .033), while those with at least one experience before being involved in my study had a 22.2% increase (M_{T1} = 1.388; M_{T2} = 1.652; W = 811.50, p = .009).

The improvement in local knowledge happened for students no matter how long they had lived in Hong Kong (see Figure 21). The positive changes increased between 15.1% to 67.5% for all the residency times, with the only exception of relatively no change for those students living in Hong Kong between 13-15 years (-0.9% change; n = 32).

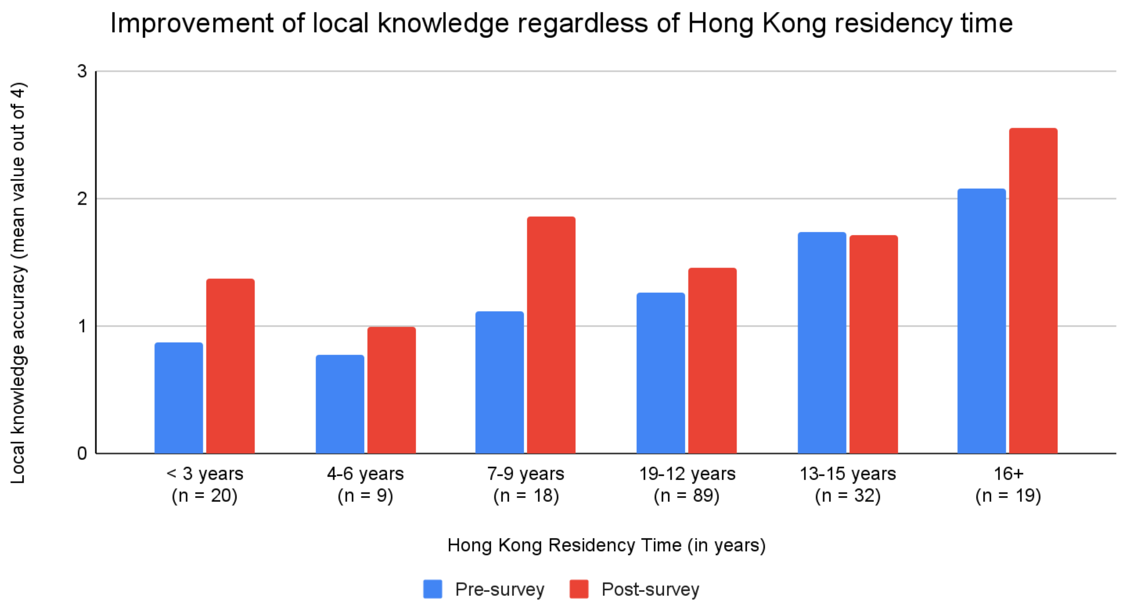


Figure 21: Bar graphs show pre-survey and post-survey changes in local knowledge based on HK residency time.

In addition to the knowledge gains shown in survey results, students participating in the HKISCNC shared in interviews that such a citizen science experience raised their awareness of the biodiversity on their own campus, noting how "we didn't know it before, there is lots of biodiversity just beside us, but we do not know it" (LS, C, YS, M). Their classmate, in a separate interview, acknowledged the existence of this general 'blindness' to campus biodiversity and explained that "we just quickly walk to our classroom and don't really observe these kinds of living things" (LS, C, YS, M). Another student, from an international school, also remarked on their greater appreciation of local fauna as a result of their citizen science experience examining biodiversity (IS, C, YS, F):

> *There's actually a lot of like, like, water creatures that we're not really aware about, usually, because I feel like, usually people focus more on like trees and flowers… But from that [citizen science] experience, we were able to look at, like, things that like mangroves, and like crabs and stuff like that.*

The final variable with a statistically significant change was for self-reported behaviours. There was a small increase (4%) in values from the pre-survey (M_{T1} = 27.6) to the post-survey (M_{T2} = 28.7; W = 9053.5, *p* = .003, r = 0.215, PS = 62). The result suggests a low to moderate effect size and the PS statistic suggests that 62% of students would have an increase in self-reported pro-environmental behaviours after a citizen science experience. Having prior experience doing a citizen science activity did not lead to a statistically significant change in self-reported behaviours, though there was a 3.1% increase for those students who had never done citizen science before (M_{T1} = 28.32; M_{T2} = 29.20; W = 1789.50, *p* = .003). Of the 10 items that measured total self-reported behaviours, six had statistically significant increases which influenced the overall change, highlighted in light green (see Table 28).

	Self-reported Behaviours (on a frequency Likert scale)
B1	I engage with nature by visiting urban parks, gardens and/or visiting environmental centres.
B2*	**I eat meat and/or seafood***
B3	**I think about how my buying habits impact the environment or biodiversity before I make any purchase.**
B4	When a school-based environmental group organises events that directly impact the environment positively (for example: beach clean-ups), I participate.
B5	I explore the Hong Kong Country and/or Marine parks to enjoy time in nature.
B6	**I use my own initiative to find information and news regarding Hong Kong and/or global environmental issues.**
B7	I talk to my friends and family about doing actions that help the environment (for example: change buying/eating habits, use public transport, etc.)
B8	**Upon analysing the complex aspects about an environmental issue, I take action with people to work on the root causes.**
B9	**Solutions to Hong Kong and/or global environmental challenges are topics I independently research.**
B10	**Raising awareness about environmental issues via petitions, forums or talks, is something I take the lead in organising.**

Table 28: A list of the 10 items for self-reported behaviours. *Note that B2 was reverse coded prior to analysis, meaning that the higher frequency on the Likert scale implied a more pro-environmental behaviour with reduced meat/seafood

consumption. The items in bold are statistically significant, the items with green highlights show a slight increase, the items in regular black text show no change, and the item in orange highlight shows a slight decrease (though not statistically significant) after students' citizen science experiences.

The six statistically significant items, represented as mini bar graphs in Figure 22, provide more context for the scale of increase in frequency for each self-reported behaviour. Note that for the "I eat meat and/or seafood" item (B2), the red post-survey bars show a shift towards lower frequencies, meaning a more pro-environmental mindset to reduce one's meat and/or seafood intake. These graphs reveal that after a citizen science experience, the majority of students are carrying out pro-environmental behaviours at the frequency levels of 'sometimes', 'rarely' and 'never' for items B6, B8-B10; and for item B2 at 'sometimes', 'often' and 'very often' (see Figure 22).

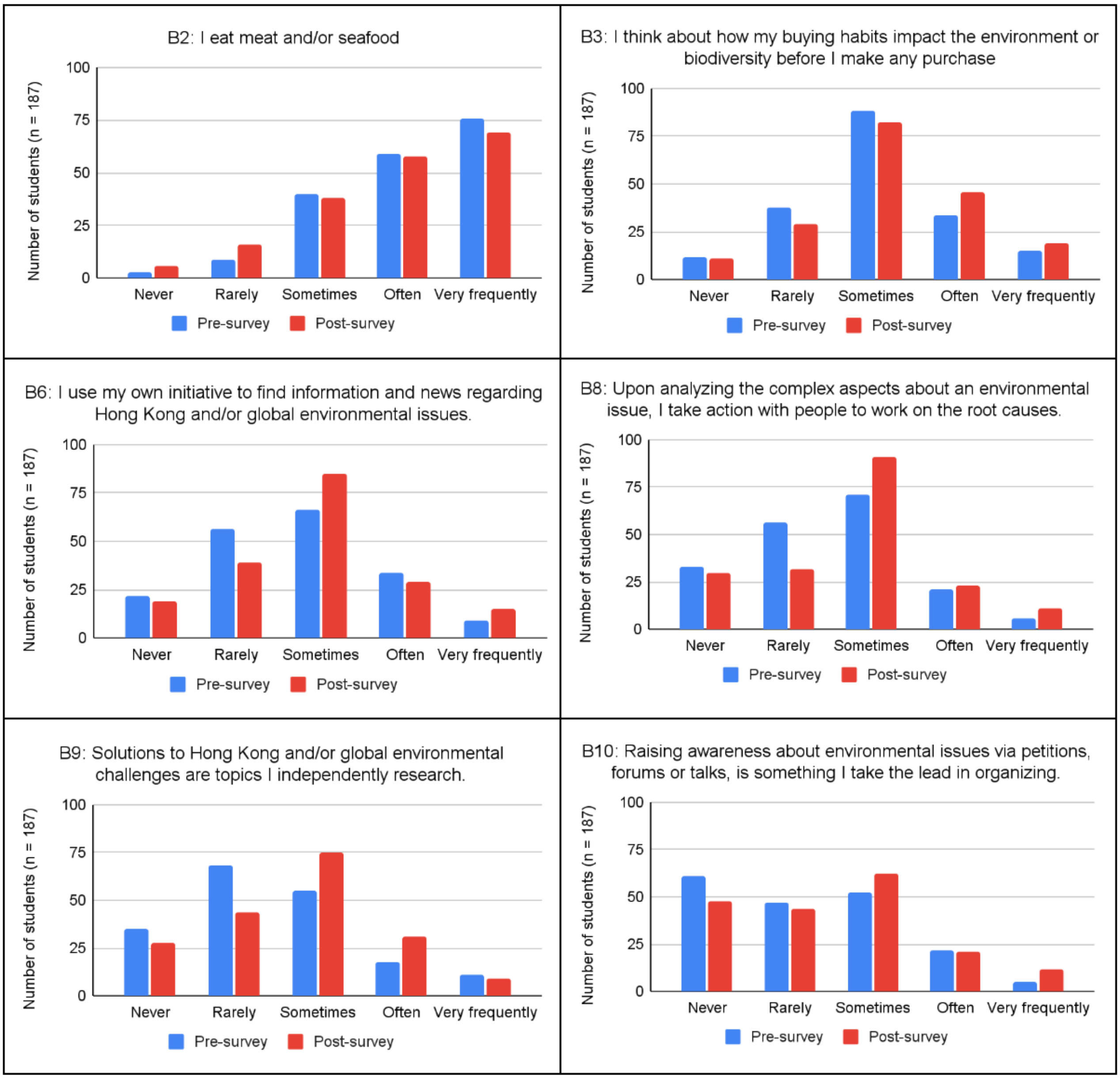


Figure 22: Each of the six statistically significant items as part of the measurement for self-reported behaviours represented in pre-survey and post-survey bar graphs of frequency.

Items with no statistically significant change after the citizen science experiences were B1, B4, B5 and B7. These four behaviours made up the top five most common actions done by students when combining the frequencies of 'often' and 'very frequently' (see Figure 23).

Positive changes for self-reported pro-environmental behaviour occurred despite a small decrease in preservation values after the citizen science experience. With the preservation values already being quite strong (see Figure 19 and Figure 20), these findings suggest that environmental citizen science projects could narrow the environmental value-action gap.

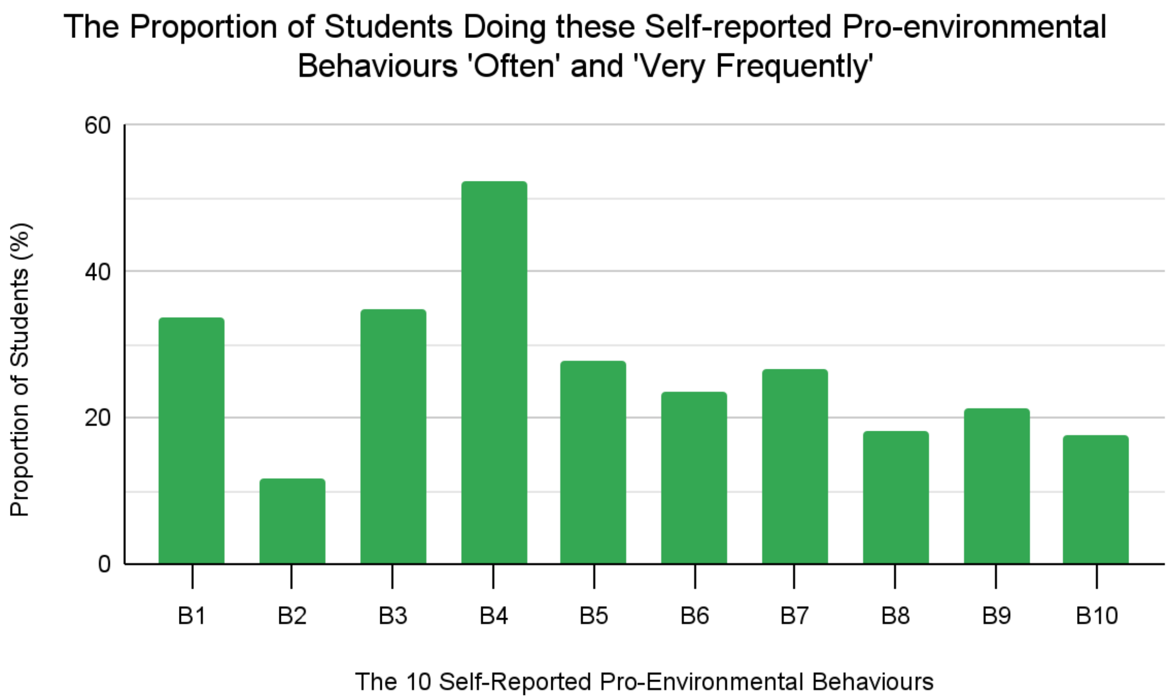


Figure 23: A bar chart showing the behaviours that students reported to do 'often' and 'very frequently'. Note that B2 has been reverse coded, so it represents the proportion of students who 'never' or 'rarely' eat meat/seafood.

Using the citizen and action constructs from citizenship education (Westheimer and Kahne, 2004) and service learning (Kaye, 2010), Table 27 links the ten self-reported pro-environmental behaviours with their action categories and types. The five most frequently carried out actions were from personally responsible and participatory categories, corresponding to direct and indirect types of action. The behaviours with positive statistically significant changes were from the personally responsible, participatory and justice-oriented categories. The behaviours that did not change after a citizen science experience (see un-bolded items) were from participatory and personally responsible categories. These findings show that citizen science experiences positively effect self-reported pro-environmental behaviours from a wide range of citizen and action framework categories.

	Self-reported Behaviours	Citizen Categories (Westheimer and Kahne, 2004)	Action Types (Kaye, 2010)
B1	I engage with nature by visiting urban parks, gardens and/or visiting environmental centres.	personally responsible	direct
B2	**I eat meat and/or seafood**	**personally responsible**	**indirect**
B3	**I think about how my buying habits impact the environment or biodiversity before I make any purchase.**	**personally responsible**	**indirect**
B4	When a school-based environmental group organises events that directly impact the environment positively (for example: beach clean-ups), I participate.	participatory	direct
B5	I explore the Hong Kong Country and/or Marine parks to enjoy time in nature.	personally responsible	direct
B6	**I use my own initiative to find information and news regarding Hong Kong and/or global environmental issues.**	**justice oriented**	**research**
B7	I talk to my friends and family about doing actions that help the environment (for example: change buying/eating habits, use public transport, etc.)	participatory	advocacy
B8	**Upon analysing the complex aspects about an environmental issue, I take action with people to work on the root causes.**	**justice oriented**	**indirect**
B9	**Solutions to Hong Kong and/or global environmental challenges are topics I independently research.**	**justice oriented**	**research**
B10	**Raising awareness about environmental issues via petitions, forums or talks, is something I take the lead in organising.**	**participatory**	**advocacy**

Table 29: A list of the 10 items for self-reported behaviours corresponding with their action categories and types. Bold actions reflect those with statistically significant changes towards a more pro-environmental behaviour.

Other shifts in actions students reported as a result of their citizen science experiences went beyond the specific behaviours measured in the survey and connected to their personal interests in nature. In one example, a student decided to stop picking up shells from the beach because of the negative impact it would have on local biodiversity. They shared that when (IS, C, YS, F):

> *I went to the beaches, I would sometimes pick up the shells and maybe take it back home because I really liked them. Yeah, then after a while, I found out that it's actually not good and like the shells might be homes for the ocean life. And then I realized that during the Deep Learning [the school lesson when they did the citizen science activity], because I, we found a lot of hermit crabs and they are in the shells.*

5.4.2 Changes by School Type: Local and International Schools

This subsection considers the impact of citizen science experiences on students attending the two different school types: local schools (22 students) and international schools (165 students). The results of the related samples Wilcoxon signed rank tests are summarised in Table 25 and Table 26. For local school students, only one variable was statistically significantly different after the citizen science experience, an increase in local knowledge. For international school students, there were statistically significant changes for (i) preservation values, (ii) confidence in self-efficacy skills, (iii) local knowledge, (iv) total knowledge, and (v) self-reported behaviours. The means for preservation values and confidence in self-efficacy skills decreased, while the means for local knowledge, total knowledge and self-reported behaviours increased.

There was a 14% increase in total local knowledge between the pre-survey (M_{T1} = 2.57) and the post-survey (M_{T2} = 2.93; W = 83, p = .05, r = 0.418, PS = 74). The effect size is considered to be between moderate and high. The specific question with a statistically significant change asked students to name any three environmental NGOs operating in Hong Kong, with an increase between the pre-survey (M_{T1} = 0.16) and the post-survey (M_{T2} = 0.52; W = 63.5, p = .005). The remaining three questions did not have a statistically significant change because the students generally had a higher level of accuracy across the questions in the pre and post-surveys (see Table 30).

Local Knowledge Questions	**Local Schools**		**International Schools**	
	Pre-survey (out of 1)	**Post-survey (out of 1)**	**Pre-survey (out of 1)**	**Post-survey (out of 1)**
Name any three environmental NGOs operating in Hong Kong. *(open ended question; score out of 1)*	0.16	0.52	0.06	0.11
What is the name of the government department responsible for environmental issues in Hong Kong? *(Multiple choice between: Green Power Department, Environmental and Biodiversity Department, Environmental Protection Department, Environmental Policy Department, I do not know; score out of 1)*	0.82	0.77	0.47	0.48
Which of these kinds of protected areas DO NOT EXIST in Hong Kong? *(Multiple choice between: National Park, Marine Protected Area, Country Park, Marine Reserve, I do not know; score out of 1)*	0.77	0.68	0.27	0.34
Choose the 3 materials that are seen in the combination recycling bins common around	0.82	0.95	0.39	0.52

Hong Kong? *(Multiple choices combinations between metal, electrical equipment, paper, cardboard, food waste, plastic, clothes and glass; score out of 1)*				

Table 30: A chart comparing local school and international school students' means for pre-survey and post-survey local knowledge accuracy.

For international school students, there was a 22.9% increase in total local knowledge between the pre-survey (M_{T1} = 1.18) and the post-survey (M_{T2} = 1.45; W = 3525.5, p = .004, r = 0.227, PS = 63). For total knowledge, there was also a 15.7% increase (M_{T1} = 2.10; M_{T2} = 2.43; W = 4235.5, p = .001, r = 0.248, PS = 62). The effect size is considered to be between small and moderate for both variables. The specific questions with statistically significant change asked students to name any three environmental NGOs operating in Hong Kong and to identify the types of materials being collected in the commonly-used three recycling bins across Hong Kong. Students performed better in the post-survey than in the pre-survey for both the Hong Kong NGOs question (M_{T1} = 0.06; M_{T2} = 1.11; W = 193.5, p = .024) and the recycling bin question (M_{T1} = 0.39; M_{T2} = 0.52; W = 892.50, p = .005). The changes in knowledge are small in part due to only four items used to determine the total. It is of note that, even with post-survey improvements in means, on average the international school students scored half as well as the local school students for local knowledge questions (see Table 30).

Students at local schools exhibited no other statistically significant changes between their pre and post-surveys for any other variable measured. This may also be a factor of the small number of participants who responded to the pre and post-surveys from local schools (n = 22), compared with the international school students (n = 165) in my study.

In contrast, international school students had similar results as seen for the total sample (see previous subsection 5.3.1), there was a small statistically significant decrease (2.5%) in the preservation value between the pre-survey (M_{T1} = 19.90) and the post-survey (M_{T2} = 19.40; W = 3190, p = .012, r = 0.196, PS = 61). The P3 statement was again the main influential item for this variable (M_{T1} = 4.2; M_{T2} = 3.0; W = 979; p = 0.005).

Confidence in self-efficacy skills was 4.4% less in post-surveys (M_{T2} = 18.3) compared with the pre-surveys (M_{T1} = 19.1; W = 3285, p = .006, r = 0.215, PS = 62). The decrease was small and statistically significant, as students reported between 'neutral' and 'somewhat agree' for feeling confident specifically in skills for (i) research and inquiry; (ii) planning and organisation; and (iii) teamwork and collaboration.

Students at international schools had a small statistically significant increase in self-reported behaviours after their citizen science experiences (M_{T1} = 27.5; M_{T2} = 28.8; W = 6945.5; p = .006; r = 0.214, PS =

62). The PS statistic implies that 62% of international school students would show an increase in self-reported pro-environmental behaviours after a citizen science experience.

5.4.3 Changes by Citizen Science Project Type: Contributory and Co-created

This subsection considers the impact of citizen science experiences when the data was split into two groups by project type: contributory projects and co-created projects. The results of the related samples Wilcoxon signed rank tests are summarised in Table 25 and Table 26. Contributory citizen science projects usually involve participants in data collection, while co-created initiatives often include participants in parts of the whole process from project development to output. I hypothesise that with greater involvement in the project components, students doing co-created citizen science projects will have larger changes across the variables, than those involved in contributory projects.

For students in contributory citizen science projects, there were statistically significant changes for (i) preservation values, (ii) confidence in self-efficacy skills, (iii) local knowledge, (iv) total knowledge, and (v) self-reported behaviours. The means for preservation values and confidence in self-efficacy skills decreased, while means for local knowledge, total knowledge and self-reported behaviour increased.

For co-created citizen science projects' students, there were statistically significant changes for (i) preservation values, (ii) importance in self-efficacy skills, (iii) local knowledge, (iv) total knowledge, and (v) self-reported behaviours. The means for preservation values and confidence or importance in self-efficacy skills decreased, while the means for local knowledge, total knowledge and self-reported behaviours increased.

5.4.3.1 Contributory Citizen Science Projects

Six of the eight schools participated in contributory citizen science projects (see Table 14), meaning that a total of 163 students (93% of the total participants who took the survey) partook in either experiential biodiversity or online air quality contributory citizen science projects. All these projects were one-off experiences which occurred on one day, with activities ranging from 30 minutes to an hour. After their respective citizen science experiences, statistically significant changes were measured for preservation values, confidence in self-efficacy skills, local knowledge, total knowledge, and self-reported behaviour. The means for preservation values and confidence in self-efficacy skills decreased after the citizen science experience, while the means for local knowledge, total knowledge and self-reported behaviours increased (see Table 26).

Pre-survey means for preservation values (M_{T1} = 19.84) were slightly higher than post-survey means (M_{T2} = 19.45; W = 3769; p = .037; r = 0.196, PS = 61), demonstrating a 2% decline after a citizen science experience. This was mainly influenced by statement P3: "Refusing to use single-use plastic items is a useful way to take action about reducing waste", as described in previous subsections (section 5.4). Despite the decrease, the students who participated in contributory citizen science projects still have an overall high level of preservation values, with between 66.7% - 79.3% of responses in agreement (somewhat agree and strongly agree combined) with the Preservation value items, except for item P4: 'My connection to nature is an important part of who I am,' with 46.6% of students in agreement.

There was a small decrease (3.6%) in confidence in self-efficacy skills after the citizen science experience (M_{T1} = 19.23; M_{T2} = 18.53; W = 3757; p = .019; r = 0.197, PS = 61). The particular skills which influenced this slight decline included (i) research and enquiry (p = .035); (ii) planning and organisation (p = .007; and (iii) teamwork and collaboration (p = .026). Before and after their contributory citizen science experiences, students mostly responded between 'neutral' and 'somewhat agree' about their confidence across the specific self-efficacy skills.

Local and total knowledge means increased after students' citizen science experiences. Post-survey local knowledge (M_{T2} = 1.53) was 21.3% higher than the pre-survey local knowledge (M_{T1} = 1.26; W = 1990, p = .002, r = 0.164, PS = 59). This increase was influenced by the improvements in the Hong Kong NGOs question (M_{T1} = 0.52; M_{T2} = 0.135; W = 63; p = .001) and the recycling bin question (M_{T1} = 0.43; M_{T2} = 0.499; W =390; p = .003), a similar pattern seen for international school students (see section 5.4.2). For total knowledge, there was a 14.4% increase in means between the pre and post-surveys (M_{T1} = 2.15; M_{T2} = 2.46; W =2424; p = .002; r = 0.167, PS = 59).

The post-surveys reported a small, but statistically significant 3.7% increase in the means for self-reported behaviour (M_{T1} = 27.64; M_{T2} = 28.67; W = 4762.50; p = .012; r = 0.135, PS = 57). The PS statistics suggests that 57% of students would have an increase in self-reported pro-environmental behaviours after participating in a contributory citizen science project. Additionally, a student directly attributed their co-created citizen science project as what was “successful in motivating people” to take action and address the plastic pollution issue they were investigating (LS, Co, OS, M).

5.4.3.2 Co-created Citizen Science Projects

Two of the eight schools worked with an environmental NGO and an environmental start-up company, respectively, to develop their co-created citizen science projects considering marine ecology and/or marine waste. These projects were experiences that lasted more than one day, with students being able to work through their respective citizen science projects for a longer period of time to establish elements of the aims, methodology and/or dissemination of the results. Despite making up only 7% (n = 13) of the total participants, preservation values, importance of self-efficacy skills, local knowledge, total knowledge, and self-reported behaviours showed statistically significant differences. The means for preservation values and importance of self-efficacy skills decreased after the citizen science experience, while the means for local knowledge, total knowledge and self-reported behaviours increased (see Table 26).

Preservation values decreased by 4.8% after their respective citizen science experiences (M_{T1} = 20.85; M_{T2} = 20.08; W = 3769; *p* = .026; r = 0.436, PS = 75), however unlike for contributory projects, there was no particular item of the five preservation value questions that influenced this overall result. Also in contrast to the students who participated in contributory citizen science projects, item P3 was the only preservation value item where there was an increase seen in the post-surveys of students involved in co-created projects (M_{T1} = 4.46; M_{T2} = 4.62; though not statistically significant, *p* = .480). The P3 statement, "refusing to use single-use plastic items is a useful way to take action about reducing waste" had an average sentiment between 'somewhat agree' and 'strongly agree'.

An 8.3% decline in importance of self-efficacy skills was reported in the post-surveys (M_{T2} = 20.31) compared with the pre-surveys (M_{T1} = 22.15; W = 3828.50; *p* = .042; r = 0.399, PS = 73). The particular items that were the most influential in this decrease were 'teamwork and collaboration' (M_{T1} = 4.85; M_{T2} = 4.23; *p* = 0.033) and 'presentation and communication' (M_{T1} = 4.31; M_{T2} = 3.69; *p* = .038). A student (LS, Co, OS, M) investigating marine plastic pollution had described some challenges when trying to connect across their whole group using digital tools, noting how:

> *We need to collaborate with like the whole team, and when we have meetings online, which I'm not so able to communicate with them… it's hard to coordinate with all the teammates, because [due to Covid-19 closing schools] we don't have a meeting at school, for example, so… the response is slow, and then sometimes the people don't respond to, yeah, my text messages and to schedule a meeting is also very hard. And we don't really have a lot of meetings. So I guess there's a lot of problems involving communication.*

With regards to knowledge, there was a similar pattern of increase (17.5%) seen in the post-surveys compared with the pre-surveys, though no one particular item in local knowledge influenced the overall positive change (M_{T1} = 2.46; M_{T2} = 2.89; W = 1990; *p* = .046; r = 0.391, PS = 73). For total knowledge, the pre-survey was lower than the post-survey (M_{T1} = 3.92; M_{T2} = 4.42; W = 2424; *p* = .025; r = 0.438, PS = 75). It is worth recognising the students in co-created citizen science projects improved their average local knowledge accuracy by 17.5% compared with contributory citizen science project students who improved by an average of 21.3% for local knowledge after their project experiences. Though the percentage gain is smaller, the students doing co-created citizen science projects (with 62% of them (n = 8) coming from local schools) already scored 2/3rds more accurately in pre and post-surveys than students doing contributory citizen science projects. With effect sizes that would be considered as approaching strong levels, the probability of superiority (PS) statistic suggests that 75% of students engaged in co-created citizen science projects would have statistically significant gains in the total knowledge of environmental information.

These 13 students involved in co-created projects demonstrated a statistically significant 9% increase in the post-survey mean for self-reported behaviours (M_{T2} = 28.77) compared with the mean before their project experience (M_{T1} = 26.38; W =4762.50; p = .02; r = 0.455, PS = 76). Contrasting this with the percentage increase for contributory citizen science projects (3.7%), this is a greater increase with a moderate to large effect size. The PS statistic implies that 76% of students would report an increase in their self-reported behaviours after participating in a co-created citizen science project.

5.4.4 Changes Seen by School Level: Younger and Older Secondary Students

This subsection considers the impact of citizen science experiences when the data was split into two age groups: younger secondary students in Grades 6 to 8 (about 11 to 14 years old) and older secondary school students in Grades 9 to 12 (about 15 - 19 years old). There was a disproportion in numbers of students participating across grade levels (see Figure 14) so combining grades into younger and older secondary allowed for more even comparative analysis of statistical results. The cut-off between Grades 8 and 9 roughly coincides with the start of the more discipline-specific courses that have culminating exams. I hypothesised larger proportions of change in older secondary school students for knowledge, skills and behaviour due to more years of formal schooling experiences and the likelihood of having prior opportunities to take pro-environmental action. Younger secondary school students showed statistically significant changes in their local knowledge only. Surveys from the older secondary school students revealed statistically significant changes in their (i) preservation values, (ii) local knowledge (see), (iii) total knowledge, (iv) self-reported pro-environmental behaviours.

For younger secondary school students in Grades 6 - 8 (aged 11 - 14, n = 124), the only statistically significant change after their citizen science projects was as gains in their local knowledge. Post-survey means were 16.8% higher (M_{T2} = 1.46) than pre-survey means (M_{T1} = 1.25; W =1134; p = .048; r = 0.126, PS = 57) of these students. The statistically significant influencing items for the gains in local knowledge included the Hong Kong NGOs (M_{T1} = 0.044; M_{T2} = 0.109; W = 26; p = .022) and recycling bins (M_{T1} = 0.43; M_{T2} = 0.57; W = 258; p = .005) questions, as seen in the cases of international school students and students who participated in contributory citizen science projects.

Responses from older secondary school students in Grades 9 - 12 (aged 15 - 19, n = 63) revealed increases of 26.8% for local knowledge and 18.6% for total knowledge. In pre-surveys, they were marginally more accurate on the local knowledge questions compared with the younger secondary school students and showed 10% greater gains than their younger counterparts. Pre-survey means for local knowledge were 1.53 (out of 4) compared with post-survey means (M_{T2} = 1.94; W = 182; p = .002; r = 0.278., PS = 65). The statistically significant influencing items for the gains in local knowledge included the Hong Kong NGOs question (M_{T1} = 0.135; M_{T2} = 0.262; W = 15; p = .002) and the Hong Kong protected area type question (M_{T1} = 0.40; M_{T2} = 0.52; W = 34; p = .046). For total knowledge, the post-surveys recorded greater accuracy (M_{T2} = 3.25 out of 6) compared with pre-survey results (M_{T1} = 2.74; W = 202.50; $p < .001$; r = 0.309., PS = 67).

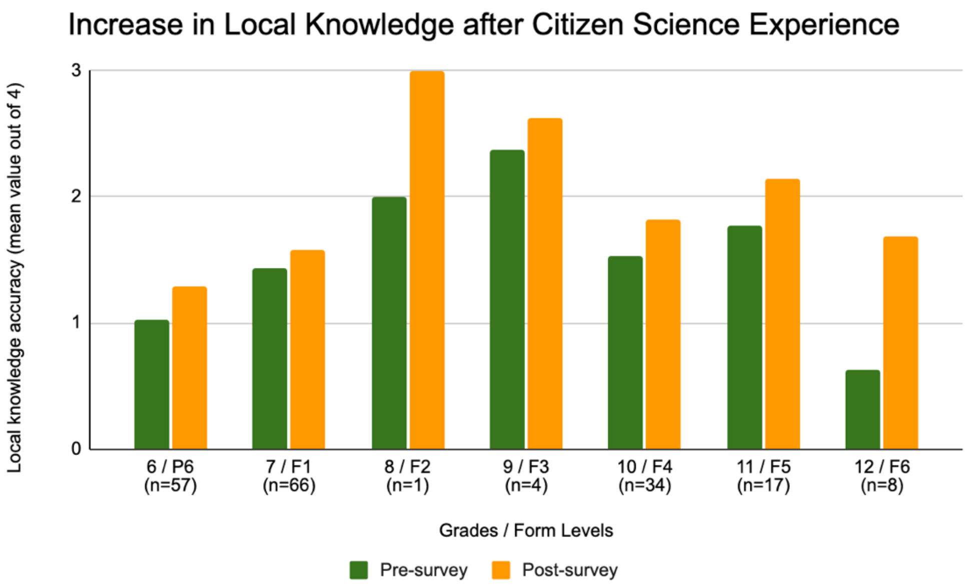


Figure 24: Bar graphs show pre-survey and post-survey changes in local knowledge based on grade levels. N gives the number of students, which for some grades is very small

As seen in the total sample, older students reported a 2.9% decrease in preservation values in their post-survey (M_{T2} = 20.22) compared with their pre-survey (M_{T1} = 20.83; W = 293; p = .006; r = 0.246, PS = 64). However, in this case, it was statement P5, 'Cleaning up the environment and protecting endangered species must be done, even if this costs money that could have been spent on supporting other important issues' that was the influencing item for this decline (M_{T1} = 4.46; M_{T2} = 4.19; W = 100; p = .011). Despite the small decline, the sentiment towards this statement remains between 'somewhat agree' and 'strongly agree', reflecting the generally high preservation values as shown in the post-survey scatterplot of the total sample (see Figure 20).

Older secondary school students reported greater frequency and range of self-reported behaviours in their post-surveys compared with their pre-surveys, with an increase of 10.1% (M_{T1} = 26.22; M_{T2} = 28.86; W = 342; $p < .001$; r =0.344., PS = 69). The PS statistic implies that 69% of older secondary school students would show an increase in self-reported pro-environmental behaviour after a citizen science experience.

5.4.5 Changes Seen By Gender

This subsection considers the impact of citizen science experiences when the data was split into the following groups: female students, male students, and those who identified as other and those who preferred not to answer. The survey responses from female students (n = 78) had statistically significant decreases in their preservation values and confidence in self-efficacy skills, and increases in the local knowledge and total knowledge. The survey responses from male students (n = 95) had statistically significant increases in their local knowledge, total knowledge and self-reported behaviours.

Female students showed a 2.6% decrease in their preservation values between surveys (M_{T1} = 20.50; M_{T2} = 19.97; W = 675; p = .032; r = 0.172, PS = 59). This slight decline was influenced by the P4 statement, 'My connection to nature is an important part of who I am' (M_{T1} = 3.72; M_{T2} = 3.50; W = 272.50; p = .026), the means of which hovered between 'neutral' and 'somewhat agree'.

Post-survey results showed a lower level of confidence in self-efficacy skills (M_{T2} = 18.12) than in their pre-surveys (M_{T1} = 19.13; W = 580.50; p = .021; r =0.185, PS = 60). Even though this represents a 5.3% decrease, the result showed female students were between 'neutral' and 'somewhat agree' about confidence in their self-efficacy skills. This decrease followed a similar pattern seen in the overall student sample, students at international schools and those participating in contributory citizen science.

As seen in the overall sample and the analyses by school type, citizen science project type and school level, female students also had gains in their local and total knowledge. There was a 36.2% increase in local knowledge (M_{T1} = 1.16; M_{T2} = 1.58; W = 234.50; p = < .001; r = 0.265, PS = 65) and an 22.7% increase in total knowledge between the surveys (M_{T1} = 2.03; M_{T2} = 2.49 ; W = 313.50; p = .001; r = 0.255, PS = 64). The local knowledge questions about Hong Kong NGOs (M_{T1} = 0.71; M_{T2} = 0.199; W = 4.50; p = .001) and recycling bins (M_{T1} = 0.474; M_{T2} = 0.503; W = 40; p = .012) were the more influential items that led to increase seen.

With a 15% increase in local knowledge and a 11.9% increase in total knowledge, the results for male students also followed a similar pattern seen across the whole dataset. The post-survey mean (M_{T2} = 1.76) was higher than the pre-survey mean (M_{T1} = 1.53; W = 737.50; p = ..35; r =0.153, PS = 58) for local knowledge. The main item statistically responsible for this gain was the question about identifying Hong Kong environmental NGOs (M_{T1} = 0.079; M_{T2} = 0.153; W = 30.50; p = .025). For total knowledge, the pre-survey mean (M_{T1} = 2.53) was less than the post-survey mean (M_{T2} = 2.83; W = 923.50; p = .038; r =0.151, PS = 58).

Pre and post-survey results reflected a 5.4% increase in self-reported behaviours for male students (M_{T1} = 27.88; M_{T2} = 29.38; W = 1308; p < .01; r =0.186, PS = 59). The PS statistic implies that 59% of male students participating in citizen science experiences would report an increase in their pro-environmental behaviours.

There were no statistically significant changes after citizen science experiences for students who identified as Other (n = 3) or preferred not to state their gender (n = 11). It is likely that the number of participants in these two groups were too small to record any representative patterns of change.

To summarise, citizen science experiences led to small declines in preservation values and confidence in one's capacity and skills to successfully take action (self-efficacy), and small increases in local knowledge and self-reported pro-environmental behaviours. These overall findings were broadly consistent when analysed by school type, citizen science project type, school level and gender. I discuss the significance of these results in the discussion (see Ch. 8.2).

5.5 Impact of Citizen Science on Variables Influencing Pro-Environmental Behaviour

In addition to conducting statistical tests to understand changes after a citizen science experience, another goal of this research was to find out which variables in the adapted Environmental Behaviour Framework (see Figure 8) influence self-reported behaviours and to what degree. Table 31 shows the variables from the framework categorised as dependent and independent variables.

Behavioural intention values were highly correlated with self-reported behaviour values and overshadowed the influence of other variables in the Environmental Behaviour Framework, so I omitted the variable 'behavioural intention' from the pre and post-survey multiple linear regression tests. Due to high multicollinearity and the variance inflation factor (VIF) values which negatively affect model fit, the variable 'importance of self-efficacy skills' was also omitted from the multiple regression tests to determine the influence of the remaining variables on self-reported pro-environmental behaviour. shows the independent and dependent variables used in the multiple linear regression tests. I incorporated these changes into an updated Environmental Behaviour Framework that I offer as a theoretical contribution, which I discuss in the Discussion (see Ch. 8.4.1).

Dependent Variable	Behaviour	Self-reported Pro-environmental Behaviour
Independent Variables	Environmental Values	Preservation Values Utilization Values
	Situational Variables	Personal Experiences Household Experiences Total Knowledge
	Psychological Variables	Intrinsic Motivation Social Influence Response Efficacy Self-efficacy Skills

Table 31: The adapted Environmental Behaviour Framework I used to investigate the influence of environmental values, situational variables and psychological variables on behaviours (intentional and self-reported).

From results of separate multiple linear regression tests on pre-survey and post-survey data, there are statistically significant changes about which variables have an influence on self-reported behaviour after a citizen science experience and by what proportions (see Figure 25 and Figure 26).

PRE-SURVEY	OVERALL	SCHOOL TYPE		CS PROJECT TYPE		SCHOOL LEVEL		GENDER			
Most Influential Variables on Self-reported Behaviour	OVERALL (n = 187)	LOCAL SCHOOLS (n = 22)	INTERNATIONAL SCHOOLS (n = 165)	CONTRIBUTORY CS PROJECTS (n = 174)	CO-CREATED CS PROJECTS (n = 13)	YOUNGER SECONDARY Gr. 6 - 8 (n = 124)	OLDER SECONDARY Gr. 9 - 12 (n = 63)	FEMALE (n = 78)	MALE (n = 95)	OTHER (n = 3)	PREFER NOT TO SAY (n = 11)
#1	Personal Experiences (0.376)	not statistically significant	Personal Experiences (0.390)	Personal Experiences (0.367)	not statistically significant	Personal Experiences (0.386)	Household Experiences (0.321)	Personal Experiences (0.469)	Household Experiences (0.443)	not statistically significant	not statistically significant
#2	Household Experiences (0.261)		Household Experiences (0.254)	Household Experiences (0.264)		Household Experiences (0.258)	Personal Experiences (0.308)	Self-efficacy Confidence (0.277)	Personal Experiences (0.278)		
#3	Self-efficacy Confidence (0.159)		-	Self-efficacy Confidence (0.167)		-	Self-efficacy Confidence (0.281)	-	-		
#4	-		-	-		-	Preservation Values (0.246)	-	-		

Personal Experiences | Household Experiences | Self-efficacy Confidence | Preservation Values

Figure 25: A summary reflecting pre-survey multiple linear regression results of which Environmental Behaviour Framework variables influence self-reported pro-environmental behaviour and by what proportions. The variables are ranked from most to least influential, while still being statistically significant ($p < .05$) and the values in brackets are the adjusted R2 values showing how much variance of self-reported behaviour is explained by that variable (out of a total of 1), the greater the value = the greater the influence on pro-environmental behaviour.

Across the overall dataset and the rest of the comparisons of school type, citizen project type, school level and gender, the most influential variables on self-reported pro-environmental behaviour prior to a citizen science experience were (i) personal experiences in nature, (ii) household experiences with pro-environmental behaviour, (iii) confidence in one's self-efficacy skills, and (iv) one's values about preserving nature.

POST-SURVEY	OVERALL	SCHOOL TYPE		CS PROJECT TYPE		SCHOOL LEVEL		GENDER			
Most Influential Variables on Self-reported Behaviour	OVERALL (n = 187)	LOCAL SCHOOLS (n = 22)	INTERNATIONAL SCHOOLS (n = 165)	CONTRIBUTORY CS PROJECTS (n = 174)	CO-CREATED CS PROJECTS (n = 13)	YOUNGER SECONDARY Gr. 6 - 8 (n = 124)	OLDER SECONDARY Gr. 9 - 12 (n = 63)	FEMALE (n = 78)	MALE (n = 95)	OTHER (n = 3)	PREFER NOT TO SAY (n = 11)
#1	Personal Experiences (0.419)	Personal Experiences (0.481)	Personal Experiences (0.401)	Personal Experiences (0.414)	not statistically significant	Personal Experiences (0.414)	Personal Experiences (0.445)	Personal Experiences (0.466)	Personal Experiences (0.371)	not statistically significant	not statistically significant
#2	Preservation Values (0.218)	-	Social Influence (0.227)	Social Influence (0.222)		Social Influence (0.314)	Self-efficacy Confidence (0.308)	Preservation Values (0.251)	Household Experiences (0.307)		
#3	Household Experiences (0.184)	-	Household Experiences (0.187)	Preservation Values (0.192)		Household Experiences (0.218)	-	-	Utilization Values (0.186)		
#4	Social Influence (0.178)	-	Preservation Values (0.185)	Household Experiences (0.182)		Utilization Values (0.185)	-	-	-		
#5	Utilization Values (0.165)	-	Utilization Values (0.178)	Utilization Values (0.165)		-	-	-	-		

Personal Experiences | Household Experiences | Self-efficacy Confidence | Preservation Values | Utilization Values

Figure 26: A summary reflecting post-survey multiple linear regression results of which Environmental Behaviour Framework variables influence self-reported pro-environmental behaviour and by what proportions. The variables are ranked from most to least influential, while still being statistically significant (p < 05) and the values in brackets are the adjusted R^2 values showing how much variance of self-reported behaviour is explained by that variable (out of a total of 1).

Across the overall dataset and the rest of the analyses by school type, citizen project type, school level and gender, the most influential variables on self-reported pro-environmental behaviour after a citizen science experience were (i) personal experiences in nature, (ii) the influence of others, (iii) one's values about preserving nature, (iv) household experiences with pro-environmental behaviour, (v) confidence in one's self-efficacy skills, and (vi) one's values about using nature for human needs.

5.5.1 Overall Data from Total Sample

Statistically significant pre-survey results for the overall dataset (n = 187) showed that personal experiences in nature explained 37.6%, household experiences with pro-environmental behaviours explained 26.1%, and confidence in one's self-efficacy skills explained 15.9% of the variance in self-reported pro-environmental behaviours.

Post-survey results revealed that personal experiences in nature explained 41.9%, one's values to preserve nature explained 21.8%, household experiences with pro-environmental behaviours explained 18.4%, the influence of others explained 17.8%, and utilisation values towards using nature for human needs explained 16.5% of the variance in self-reported pro-environmental behaviours (see Figure 27). The variables in the white boxes without any arrows are the ones that did not have statistically significant influence on self-reported pro-environmental behaviour.

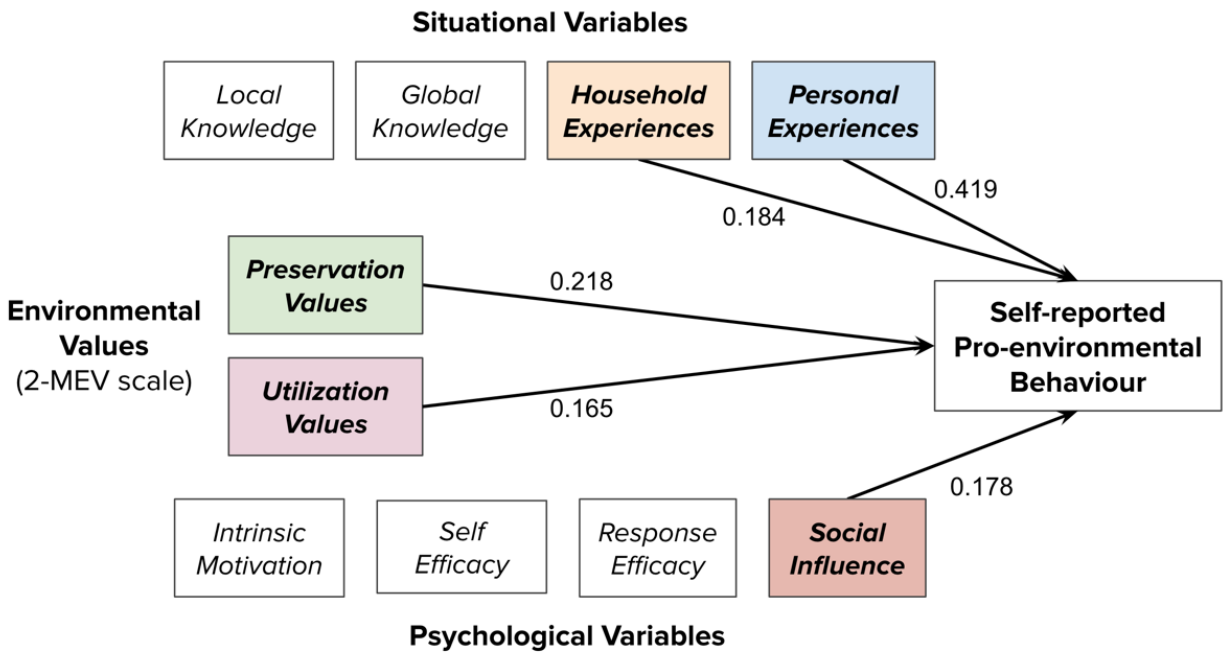


Figure 27: Simplified framework diagram showing the adjusted R^2 values with the proportion of variance explained by each bolded variable (statistically significant) towards self-reported pro-environmental behaviour.

After their citizen science experiences, students seemed to be increasingly influenced by their own experiences in nature (whether they were school field trips or their own personal or family trips) when it came to predicting pro-environmental behaviour. Students' preservation values, and specifically the statement P4, "My connection to nature is an important part of who I am", were slightly more influential in predicting their personal pro-environmental behaviour than the environmental habits they saw amongst family members and the influence of others. The specific household experience that had the greatest influence on self-reported behaviours was 'discussing environmental issues' with one's family, which was the case before and after the citizen science experiences. Prior to their citizen science activity, students' pro-environmental behaviour was most influenced by stories of positive action seen on social media (an item within the 'social influence' variable). After their citizen science experiences, students were also influenced by people they knew (family, friends and teachers) taking positive action towards the environment. Of note is how observing others doing harm to nature does not have a statistically significant influence on predicting self-reported pro-environmental behaviour. Students' ideas about nature as a resource had the smallest statistically significant influence on their self-reported actions towards the environment. A student saw the potential of human ingenuity in using natural resources to conserve the natural environment, stating how nature "provides a lot of the resources to protect nature itself" (LS, Co, OS, M). Their investigation in biochemical solutions to the marine plastic pollution problem led them to appreciate "using nature to preserve nature" and how "human intervention is still very important because humans are also doing a lot to harm the environment".

5.5.2 School Type

Pre-survey regression results for participants in local schools (n = 22) were not statistically significant. For participants of international schools (n = 165), pre-survey regression tests found that personal experiences in nature explained 39% and household experiences with pro-environmental actions explained 25.4% of the variance in self-reported pro-environmental behaviours.

Post-surveys regression results of local school students were statistically significant and found personal experiences in nature explained 48.1% of the variance in self-reported pro-environmental behaviour. Results for students attending international schools revealed that personal experiences in nature explained 40.1%, the influence of others explained 22.7%, household experiences with pro-environmental behaviours explained 18.7%, one's values to preserve nature explained 18.5%, and one's values about using nature for human needs explained 17.8% of the variance in self-reported pro-environmental behaviours.

These tests reveal how after citizen science experiences, both local and international school students found their experience in nature to have the greatest influence on their self-reported behaviour. For local school students, specifically school-organised field trips in nature and personal experiences at environmental centres or museums had the most influence on their self-reported behaviours. This differed slightly for international school students, as personal trips in nature and to environmental centres were the two statistically significant predictors for self-reported behaviour. Additionally, for international school students, the influence of others, the environmental habits of one's household, their own perspectives about preserving and using nature were the remaining influential variables that predicted their pro-environmental behaviour. Specifically about the influence of others, an international student highlighted that they "do think there's a social pressure to be more environmentally-minded, which isn't a bad thing" (IS, C, OS, M).

5.5.3 Citizen Science Project Type

Students engaged in contributory citizen science experiences (n = 174) had pre-survey regression results that showed personal experiences in nature explained 36.7%, household experiences with pro-environmental actions explained 26.4%, and confidence in one's self-efficacy skills explained 16.7% of the variance in self-reported pro-environmental behaviours. Their post-survey regression results revealed more variables that influenced behaviour. The variance of self-reported pro-environmental behaviour was explained by students' personal experiences in nature (41.4%), the influence of others (22.2%), one's values to preserve nature (19.2%), their household's environmental habits (18.2%), and one's feelings about using nature for human needs (16.5%). A student, who participated in a one-time contributory HKISCNC citizen science project, recalled how their childhood experiences included frequent personal time in nature which was encouraged by others in their social group (IS, C, OS, F):

> *The most contact I had with nature was at a natural park. I used to go over, like, a few times a week. That also links in with, like, the influence of other people because the first time that I take part in these experiences that make me want to take part in more experiences are because some of the people invite me.*

Pre-survey and post-survey regression results for students participating in co-created citizen science projects (n = 13) were not statistically significant, likely on the account of small participant numbers.

5.5.4 School Level

Statistically significant pre-survey regression results for younger secondary school students (n = 124) showed that personal experiences in nature explained 38.6%, and household experiences with pro-environmental actions explained 25.8% of the variance in self-reported pro-environmental behaviours. For older secondary school students (n = 63), regression results stated that household experiences with pro-environmental behaviours explained 32.1%, personal experiences in nature explained 30.8%, confidence in one's self-efficacy skills explained 28.1%, and one's values to preserve nature explained 24.6% of the variance in self-reported pro-environmental behaviours.

Regression test results of younger secondary school student's post-surveys revealed that personal experiences in nature explained 41.4%, the influence of others explained 31.4%, household experiences with pro-environmental behaviours explained 21.8%, and values towards using nature for human needs explained 18.5% of the variance in self-reported pro-environmental behaviours. For older secondary school students, their post-survey regression tests highlighted personal experiences in nature (44.5%) and confidence in one's self-efficacy skills (30.8%) as the main influences on self-reported pro-environmental behaviour.

After their citizen science projects, both younger and older secondary school students' survey results indicated that their personal experiences in nature had the greatest influence on their self-reported pro-environmental behaviour. The influence of others and the experiences with family environmental actions at home (especially discussing environmental issues) were influential variables for younger students, while the self-reported behaviours of older students were more influenced by their confidence in self-efficacy skills. Younger students' values regarding the use of nature as a resource had the smallest statistically significant influence on their self-reported pro-environmental behaviour.

5.5.5 Gender

Female students' pre-survey regression results (n = 78) showed that personal experiences in nature explained 37.6%, household experiences with pro-environmental behaviours explained 26.1%, and confidence in one's self-efficacy skills explained 15.9% of the variance in self-reported pro-environmental behaviours. Pre-survey results for male students (n = 95) found that household experiences with pro-environmental behaviours explained 44.3% and personal experiences in nature explained 27.8% of the variance in self-reported pro-environmental behaviours.

Post-survey regression results for female students revealed that personal experiences in nature explained 41.9%, one's values to preserve nature explained 21.8%, household experiences with pro-environmental behaviours explained 18.4%, the influence of others explained 17.8% and values towards using nature for human needs explained 16.5% of the variance in self-reported pro-environmental behaviours. For male students, the variables that explained the variance in self-reported pro-environmental behaviour were personal experiences in nature (37.1%), household experiences with pro-environmental behaviour (30.7%) and one's values to use nature for human needs (18.6%).

The pre and post-survey regression tests for students identifying as 'Other' (n = 3) and 'Prefer not to say' (n = 11) did not have statistically significant model results, likely due to small participant numbers.

Female and male students had personal experiences in nature as their most influential psychological variable after experiences with citizen science. Despite a small decrease in their feelings about their connection to nature, female students' preservation values remained quite high, and it was an influential variable in predicting their self-reported pro-environmental behaviour after an experience with citizen science. A female student remarked that "from the [citizen science] activity, I became more aware of the nature around me, and, like how like special it is. So I guess that made me want to preserve it more" (IS, C, YS, F). This differed for male students, as their self-reported pro-environmental behaviours were more influenced by actions of their household and their values about using nature as a resource.

5.6 Chapter summary

In this chapter I shared results of two series of statistical tests and quotes from student interviews to answer questions about the impact citizen science experiences have on how secondary school students in Hong Kong feel, think and act towards the natural environment. Using related samples Wilcoxon signed rank tests, I compared pre and post-survey data to find that generally, preservation values and confidence in self-efficacy skills slightly decreased after citizen science experiences, while local and total knowledge, and self-reported pro-environmental behaviours increased. Though preservation values and self-efficacy skill confidence decreased, they were one of the influential variables on self-reported pro-environmental behaviour, while local and total knowledge, despite showing consistent improvement after citizen science experiences, never featured as an influential variable on behaviour. Multiple linear regression tests of the pre and post-survey data revealed that there was a shift in which variables were more influential on one's self-reported pro-environmental behaviour. Prior to the citizen science experience, personal experiences, household experiences and confidence in one's self-efficacy skills were most influential. However, after citizen science experiences, personal experiences in nature, the influence of others, preservation values, household experiences and utilization values were the most influential on self-reported behaviour.

CHAPTER 6

6 Results: Perspectives about Environmental Education and Citizen Science

This chapter focuses on the second sub-research question: what are teacher, student and citizen science organiser perspectives about environmental education and citizen science? The results and analysis presented in this chapter reflect the findings from teacher, student and citizen science organiser interviews conducted, supplemented by findings from the student surveys and observations made during field trips with five of the eight schools that participated in my research. This chapter introduces the viewpoints about environmental education, citizen science and citizenship action from teachers, students and citizen science organisers, respectively. Each of their accounts is framed around themes with participant quotes adding depth. Each sub-section ends with analytical comparisons of perspectives between teachers, students and citizen science organisers to draw out similarities and differences. I condense the overall findings in the chapter summary, which also includes considerations about the scope for interpretation. These overall ideas are further contextualised with reference to the literature about environmental and experiential education, citizen science and citizenship actions in Chapter 8, the discussion.

6.1 Environmental Education

This section is focused on how teachers, students and citizen science organisers feel about environmental education as a whole. I introduce themes that illustrate their perceptions about the goals, value of and opportunities for environmental education. I begin with sharing the thoughts of teachers, then students and finally the citizen science organisers. The closing sub-section compares their points of view to highlight complementary and opposing ideas, which will be discussed in association with the related literature in Chapter 8.

6.1.1 Teacher Perspectives

This subsection reports the views of the interviewed teachers and shares their experiences of being involved in formal and/or informal environmental education. Teachers stated that elements of environmental education were peppered across formal geography science and language courses, and within informal learning experiences like science or environmental co-curricular activities, for example environmental clubs and science education competitions. A minority of the schools had a specific course that dealt entirely with environmental issues: the International Baccalaureate Diploma Programme (IBDP) course called 'Environmental Systems and Societies'. The most common topics and environmental issues taught to students were about climate change, biodiversity and habitat loss, air and water pollution, single-use plastic and electronic waste management. There was much alignment regarding what environmental education should be about and how it should be taught in both local and international schools. Some divergent views about applying one's environmental issue knowledge came to the fore as the interviews progressed to questions about citizenship action, which will be lightly touched upon here and at greater depth in the next chapter (see Ch. 7.1).

Teacher perceptions about the significance, educational outcomes and challenges are synthesised in five themes as illustrated in the thematic map (see Figure 28). The five themes are (i) Raising the bamboo scaffolds; (ii) Making the impersonal, personal; (iii) Tapping into the senses; (iv) I'm not in control; and (v) Bridging the head, hands and heart.

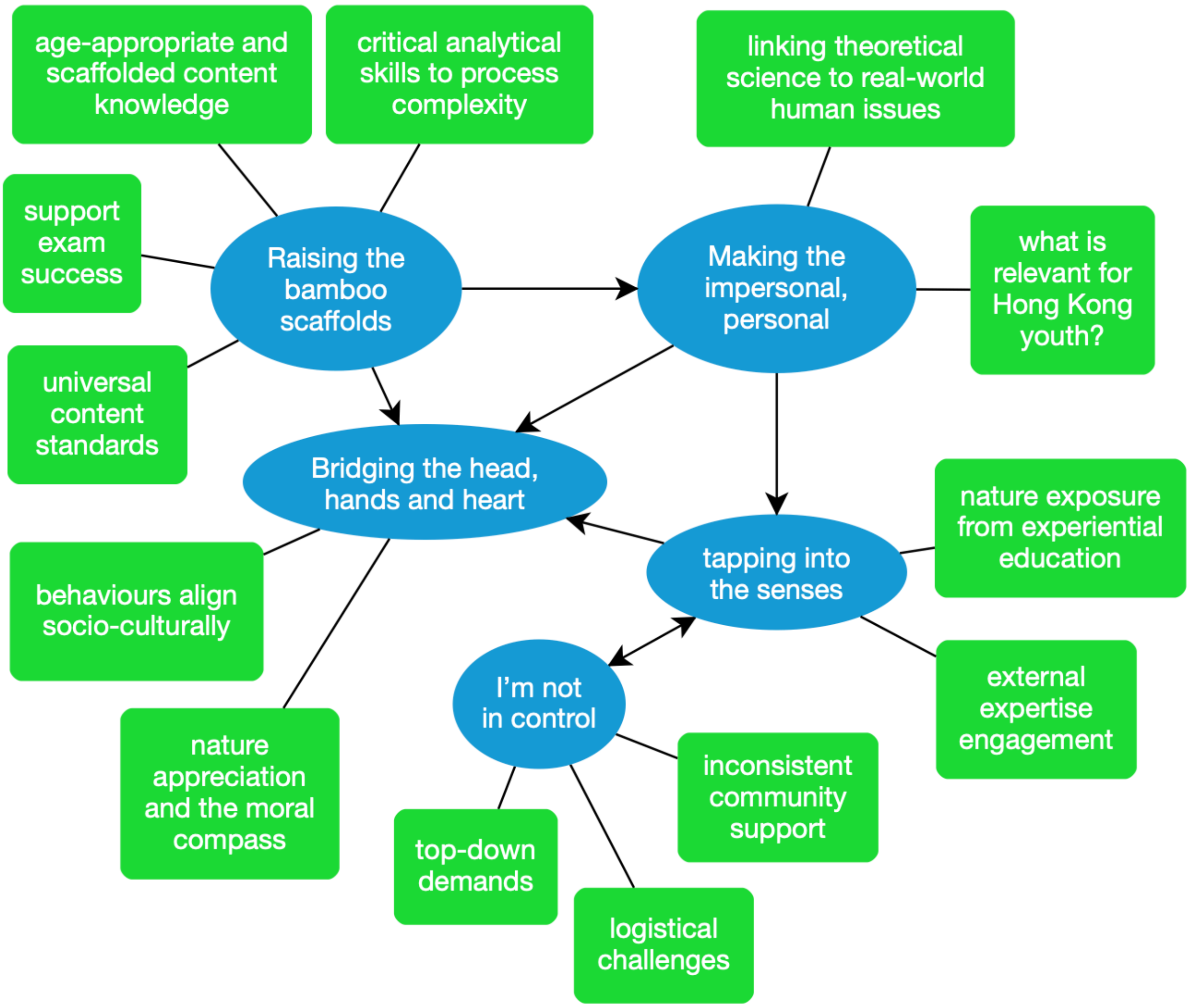


Figure 28: A thematic map of teacher perspectives about environmental education; themes are in blue ovals, sub-themes are in green rounded boxes, and the lines and arrows show association.

Raising the Bamboo Scaffolding

This theme reveals what teachers perceived the goals of environmental education to be. The 'bamboo scaffold' is an allusion to the ubiquitous construction necessity seen all over Hong Kong's iconic skyscraper landscape (see Fig. 28) and symbolises the heightening of Hong Kong students' capacity as environmentally literate learners, with strong foundations in the local bedrock. The main ideas within this theme revolve around building fundamental environmental knowledge and skills in a manner that caters to students' needs across the secondary school grades. Examples of codes and excerpts used to develop these sub-themes are shown in Table 12 in Chapter 4.

Figure 29: A collage of two photos showing bamboo scaffolding used in protection netting during construction of tall buildings in Hong Kong. Author took these photos on 29th March 2022.

Teachers felt an important outcome of any curriculum that delivers environmental education should be the construction of fundamental content knowledge about a range of common environmental issues. Part of foundation-building includes providing information about the issues in a scaffolded manner across grade levels for age-appropriateness. Since teachers follow the curriculum guidelines and learning objectives as set forth within their local or international school systems, students could be learning different kinds of environmental information. There was a call for common learning outcomes in the form of "good baselines for students to reach" (IS, C, Sci) to allow consistency in what students are exposed to. Learning different content under the banner of environmental education is especially a concern for school environments with transient populations where teachers often teach different grade levels and/or subjects every few years. While national and international curricula may differ on specific learning outcomes, the UN has published some helpful overarching guidelines for all educational contexts about specific environmental sustainable development learning objectives linked to each of the 17 SDGs (UNESCO, 2017) and teacher competences for educating about environmental sustainable development (UNECE Expert Group on Competences in Education for Sustainable Development, 2012). No matter how environmental education is taught, there is an expectation that what students study will support the learning objectives evaluated in their summative tests and exams. To facilitate such cognitive achievement, teachers highlight how educating about issues affecting the environment provides opportunities for critical thinking and analytical skill development. Another teacher (IS, C, Sci) discussed the importance of:

> *Having the ability to analyse information, they've [the students] a complex understanding of systems that are interconnected, and these other skills, and they have the ability to be sceptical, make decisions on their own. That's a massive part in the world right now, is that people really struggle with the ability to, and that's the part about understanding complex systems, and then secondly is that, being able to evaluate data, and the information coming at them from media, to make decisions on their own*

Teachers from both local and international schools highlighted that this kind of education should begin at the primary level in order to be effective at generating greater awareness and inducing a concern for the natural environment from an early age. A teacher felt "these things kind of have to be scaffolded… from preschool and you know just like you learn about life cycle of a frog… we should be doing life cycle of things… adding more complex layers as they [students] get older" (IS, C, Sci). Another teacher similarly described an ideal catered approach to include building a foundational structure of basic information at the primary grade levels (younger than 11 years old), leading to explorations for nature appreciation in early secondary school grade levels (from 11 - 14 years old), such that older secondary school students (15 - 19 years old) "develop a moral sense, and then now they know what is right or wrong. It is not because of teacher say so, but it is because they feel that" (LS, C, Sci).

A key hope in the learning process is for students to form an awareness about challenges affecting the natural environment such that they develop, as a teacher shared, "a fondness and an understanding that it [the natural environment] is something that needs to be protected as well" (IS, C, Sci). Another teacher (LS, C, Sci) linked increasing knowledge to developing pro-environmental attitudes and encouraging action, stating the goal of environmental education should be to:

> *Know what is in the environment, at least, and then after they know about what is going on in the environment and how it can benefit us and how we have been destroying them [the environment], then they will have the attitude, they will have the motivation to really help with the environment and help protect it.*

These sentiments touch upon the notion that environmental education should do more than simply cram students with information about the causes and consequences of environmental issues. Teachers, who come from across the expertise spectrum of languages, humanities and the sciences, point to the potential of environmental education to raise awareness and ultimately motivate students to apply their knowledge in the form of pro-environmental action. This idea connects to the three-pronged approach for cognitive, socio-emotional and behavioural learning objectives in the UNESCO guidelines (UNESCO, 2017).

Making the Impersonal, Personal

This theme focuses on how learning about the environment, and the issues affecting it, can be a way to localise and personalise what students learn in their classes, especially in the sciences. The theme also references how environmental education can make theoretical or abstract concepts more tangible and relevant to the students' lives.

Teachers spoke of the benefit environmental education can have in taking theoretical scientific ideas and making them more concrete by applying those concepts to real world challenges. A teacher appreciated how it provided links to environmental and human issues, reflecting how when "studying science, there is a kind of detachment from reality, but when we are studying environmental science, we try to relate the science to the environment, something that we are living here, so more related to us" (LS, C, Sci). A colleague of theirs added that these opportunities prompt self-reflection amongst the students about how humanity is affected by changes in their environments and how humanity plays a role in affecting those very environments and ecosystems. That feedback loop is how the wider environmental issues can be personalised to connect to student lives in more concrete ways. In Chapter 5.4.2 I shared student pre-survey results about local environmental knowledge, revealing how international school students knew less than their local school counterparts (see Table 30). This was the case despite the average residency time of both groups of students being about the same, implying that what they actively learn in school may play a role in what Hong Kong-based environmental information they know. Concerned about this learning deficit, a teacher (IS, C, Sci) commented:

> *Environmental education has been this like far off, irrelevant, it's a global thing, and I feel like the local connections haven't been asked. So I mean, I really think the most important thing is to make it personally relevant and that's why I think making local connections, is so important, and I think, to be honest, the best way to start is just in their own school environment. It's kind of hard to control things at home and you know too, for kids to get invested and really care about, you know, what's going on at the school I feel like that shows.*

Here the teacher points to the important role educators and schools play in aligning the learning to the realities of students' lives; it is a way to create cognitive and emotional hooks between the student and the education. Another teacher, coming from the humanities lens, supports this approach as they incorporate local field trips because it is something "they [their students] can relate to very easily" (IS, Co, Geo). Making the learning personally relevant is a pivotal element to keeping students engaged and, from the teachers' perspectives, an impactful way to do that is through more unconventional approaches like experiential education.

Tapping into the Senses

This theme describes how experiential education is an effective learning mode for environmental education because of its multisensory dimensions. Teachers expressed a distinction in the educational experience between in-situ versus classroom learning. This theme also links to the tapping of external expertise to provide supplementary insight and skill.

Experiential education, where learning about a topic is done in multisensory ways and includes opportunities for reflection, was recognised by teachers to not only support student learning, but their own. A local school science teacher remarked that the motivation to tackle the local coastal marine plastic pollution came from their own experience of visiting a beach full of plastic bottles in western Hong Kong. Sharing their photos and videos of the environmentally problematic scene with their students involved in a science competition, they suggested focussing on this rampant issue by bringing them to the various Hong Kong beaches to see it with their own eyes to "visualise the real situation. I think that is important. This is far more better than the just look at the PowerPoint or look at the photo… then maybe ask them to take action" (LS, Co, Sci)

Another teacher (LS, C, Sci) suggests that seeing is only one part of the experience, and may not be as important as hands-on interactions that trigger thoughts and feelings:

> *They go out and spend some time on the beach, they sweat, they know what is happening because they feel it. So I think that the physical movement, the activity, this kind of connected to the brain, so they can remind them of what is happening in the world. Because, if you tell them, "I have a photo of the rubbish", or a dolphin died, ok so, this is a photo. And then, they will swipe to another pictures, let's say Instagram and they will look at it. But if they go out directly, if they do some physical activities and feel it, I think this is really practical for students to know what is happening. To feel what is happening in the outside world, they can feel it, they can see it by their eyes, and I think more, they are using their senses.*

One objective for teachers is for students to see the negative facets of environmental problems in a manner that leaves an impression and prompts calls to action, while experiential education can also be about encounters that stimulate appreciation and positivity. Five of the eight schools in this study participated in citizen science projects about biodiversity in and around one's school campus, with four of them officially taking part in the Hong Kong Inter School City Nature Challenge (HKISCNC) initiative. Teachers, especially those at local schools, described many instances of their students being (i) happy amongst flora and fauna; (ii) excited when observing birds, bats, insects and fish on-campus;

(iii) collaboratively helping each other to make observations of fast-moving species like flying insects; and (iv) curious about additional observations they personally made since their school-based citizen science field trip experience.

To provide a change of perspective and a different learning environment than what the students get used to in the classroom, teachers often look to the community to tap external expertise. Specifically, teachers mentioned inviting environmental organisations and specialists to present their knowledge about various local issues with NGOs like WWF, Greenpeace and Plastic Free Seas, describing what actions one can take to mitigate the problems. These events often take the form of whole school assemblies or grade/class level presentations by the guest speakers, with some being interactive. More unique opportunities have come from established partnerships between organisations and schools, where students have had the opportunity to, for example, learn how technology can be used to address local pollution problems with environmental start-up companies, support ecosystem restoration projects and engage in additional citizen science initiatives for monitoring marine and coastal ecology. Building relationships with like-minded outside entities to provide "meaningful activities, not just slave-labour" takes some time and teachers raised concerns that schools may be viewed as an ever-ready "rent-a-crowd" (IS, C, Lang). All students in secondary schools have some level of community service or service learning requirements as part of their secondary school experience, thus organisations know there are thousands of students annually looking for volunteering opportunities. Yet, the benefits outweigh the potential negatives (when due-diligence about the educational quality of the activity is done), and as a teacher summed up, experiential education is “the best teacher" (IS, C, Lang).

I'm Not in Control

This theme reveals the challenging aspects about creating experiential forms of environmental education. Teachers shared the difficulties navigating the top-down demands from their national curricula and school leadership, logistical constraints and inconsistency of community support.

One of the most common factors teachers noted was the lack of time to develop environmental field trips and/or experiential activities due to short lesson times and curricular pressure. With the demands of addressing the knowledge-heavy and assessment-focused learning objectives, a teacher contemplated how with "such a tight schedule to stick to, to get the content done… do I even get that [experiential education] in?" (IS, Co, Geo).

> *1: I think we've got a very outdated curriculum at GCSE.. It is content driven and it shouldn't be.*
>
> *2: It's very much 'this is tourism. Know the definition'.*

> *1: It's just knowledge, knowledge, and we've known for quite some time that's not the best way to be teaching the kids. And we've been told we we need to promote skills and we, Okay, well, great but it is not happening in your, in your curriculums that you're, you're testing... We're kind of tied into that's what we [get] judged on. So we can't [fit in experiential education easily].*
>
> *2: It needs to definitely be more decision-making exercises. Here's some information, what are you now going to do with this information? And it doesn't even give you the opportunity, because it's such, no matter what spec you do at GCSE is very much they need to know this. It's very 1950s. This is how a river works, and great.*

The above conversation between two international school humanities colleagues (IS, Co, Geo) revealed disaccords between what they have the time to teach and what they wished they could focus on with their students. A curriculum assessing content-knowledge rather than one centred around the learning and application of skills in problem-based or enquiry learning was perceived as a limitation by these teachers. Another teacher (IS, C, C), who is also part of the school's leadership team as a learning coordinator, acknowledged that similar pressure about the need to follow set curriculum:

> *To a certain extent a lot of it would be dictated by the official curriculum, i.e. set by the IB [International Baccalaureate]… you have to do this, you have to cover this, you have to cover ecology, have to do human-impacts on the environment, specifically this thing, this thing and that thing going on. We've got to hit those objectives as teachers.*

The extent to which environmental education is covered when the school curriculum does encourage connecting to such themes was cast in doubt by a teacher (IS, C, Sci) who critiqued the broad interpretations of concepts like 'sustainability' and 'globalization' which are terms published in curriculum documentation. Within the International Baccalaureate curriculum, one of the learning 'global contexts' to choose from is:

> *Globalization and sustainability. So even if that's the context, it doesn't always mean that environmental education actually happens. [A teacher could be] focusing more on the globalization.*

Some challenges are related to the way in which environmental initiatives are addressed by the school leadership. A teacher shared the problematic nature of how if leadership "don't know that there are anyone [teachers] who wants to do this, so they just sort of ignore it for now" (LS, C, Sci). Their experience seems to describe a circumstance akin to a 'chicken and egg' situation, in terms of what needs to come first, initiatives by leadership or teachers to prompt the other. For other teachers, they felt school administrators favoured environmental issue knowledge acquisition instead of learning about solutions and actions, as one said, "they prefer the, like, really in-depth issue talk more than the 'this is how we can fix it' talk" (IS, C, Sci). Furthermore, when school leadership have ideas about environmental education and sustainability, some teachers found the initiatives to be limited to add-on activities. One teacher felt that "the school atmosphere is obviously not very supportive of the environment and protecting things, because no one really talked about them… no one takes any initiative" (LS, C, Sci). What teachers desired is an environmental education mantra across the whole school's pedagogical and operational approach to be truly effective.

Given that colleagues are "all busy people who already have a lot of job to do in their hands" (LS, C, Sci), teachers who are motivated to drive formal or informal environmental education expressed feeling somewhat unsupported. They explained how the many logistical demands for nature-based excursions are significant barriers, and that teachers often opt for a visit to an established nature-themed edutainment park "because it's easy, we just need to, you know, bring them to the 'Ocean Park' and then our job is done". Another limitation is the time and effort it takes for teachers to involve external organisations in the experiential environmental experiences, "as creating relationships… it takes time… and you have to believe that doing so will provide the students with meaningful opportunities" (IS, C, Lang).

Bridging the Head, Hands and Heart

The first three themes in this subsection, 'Raising the bamboo scaffolds', 'Making the impersonal, personal' and 'Tapping into the senses', merge towards this final theme, which captures the idea many teachers shared during the interviews; an ideal outcome of environmental education involves bridging the mind, the heart and the hands. Getting opportunities to engage in environmental issues by being in-situ connects the content and conceptual learning with the development of a consciousness about the value of nature. One teacher hoped to, "make students aware and appreciate nature so that they want to conserve it. Because if they don't understand it, they won't love it, and if they don't love it, then they won't conserve it" (IS, C, Sci). Another agreed, suggesting that "it would be great if we educate students about the environment… so that they're all aware. And once they grow, like in the future, they will be more like, sustainable" (IS, C, Sci). Reflections about such environmental values, especially in a guided exercise, allows students to process how they are personally linked to these very environmental issues and prompts the consideration of what their responsibilities to address them are.

Teachers perceived quantity and quality of nature exposure from a young age as an influencing factor for the nurturing of nature appreciation. Responses from teachers revealed that they were conscious of the difference between the majority of their students who grew up and lived in more urban areas of Hong Kong and those who were raised in the more rural areas with immediate access to natural vegetation. The students living close to nature would often make reference to experiences with wildlife such as snakes and birds when sharing stories with their class. Teachers also noted that experiences like the HKISCNC required all students to engage with their campus biodiversity by looking amongst the trees, plants and grassy ground, where they most often found insects, an animal group that some urban-living students find scary. During my field observations when I noted how students interacted during their HKISCNC sessions, I noticed that despite their initial fear, many students would still follow-through with making an observation on their smartphones or cameras, even if at a distance. Sometimes that distance would reduce after taking a few observations and I perceived a little more sense of comfort as they engaged in the activity. Even the volume of surprised gasps and shrieks upon sighting an insect lowered. One teacher (LS, C, Sci) recalled how:

> *Last year, when I have my class… they are so afraid of touching the soil, the glass, the shrimp, the fish, they are really scared that kind of natural things. I hope that they can at least, they can feel confident to touch it. Rather than, like scared and screaming and shouting around. I think this is important because they don't really have the chance to feel the nature.*

These sentiments suggest that short phases of guided and school organised interactions with nature can have an impact on young people's impressions.

The link between recognizing an environmental issue and responding with pro-environmental action was often a sequential process, from the teachers' perspectives. A teacher defined the goal of environmental education as arousing "awareness… about the situation of the, of the environmental issue, and also to engage them [the students] to participate in voluntary action to take action" (LS, Co, Sci). This sentiment is reinforced by another teacher who placed the responsibility on teachers to design learning opportunities that instil a desire in students to use their knowledge about environmental issues and skills for positive change. They felt strongly that teachers would be "failing them if we weren't actually creating a sense of ownership and responsibility in the students" (IS, Co, Geo). Here, this particular teacher alludes to the development of a moral compass to guide students' decision-making when responding to a call for citizenship action. Teachers felt that knowledge alone was not enough to spark pro-environmental behaviour. They placed value in nurturing the belief that one's actions can make a difference (known as response efficacy) and that one can learn the necessary skills to have a tangible impact (known as self-efficacy). Though teachers all spoke of their hope that students take action about issues they care about, one teacher (IS, Co, Geo) felt it vital to teach students about distinguishing where the responsibility lies. Their concern suggests they acknowledged the potential negative impact of cognitive and emotional overload that paralyse students from taking action. To remedy this, they used the understanding of roles and responsibilities as a method to build confidence that what actions students do take have meaning and impact.

> *For me, it's always been making sure that students actually know what is their responsibility, but equally so, what isn't their responsibility. And they get hammered with so much like, you need to do this, you need to do that, you need to do this. And there's actions that they physically can't do, because either they're not in those*

roles yet, they're not of the age to be employed to make those decisions. And it's like, recycling is a good one. There's a common argument, you know, where everybody's like, "but Hong Kong doesn't recycle this and this" and I say to students, that's not your responsibility, your responsibility is: you have plastic bottle in front of you, you recycle it, you do what you can do in your capacity. And then if somebody else has a different role to you, what are you going, going to do in your capacity to hold them accountable? And then should you get into that role, do you know what your responsibility is?

Teachers wondered if students may be dissuaded from devoting time and effort to take action depending on how they were exposed to an environmental issue and attempts to address it. The topic about barriers to citizenship action is discussed at great length from teacher, student and citizen science organisers in the next chapter (see Ch. 7.1.3). Creating purposeful learning engagements that make space for powerful emotional experiences that prompt students to apply their learning to address an environmental issue can "engage them [the students] to solve the problem… and then let them see that they can change the world a bit" (LS, C, Sci). The teachers themselves are inspired by the call to incorporate more environmental education in their language, geography and science courses from a sense of doing what is right by the students and by the planet.

6.1.2 Student Perspectives

This section is about the quality and perceived impacts of environmental education as experienced by Hong Kong secondary school students. Students attending local schools mentioned that geography, humanities and science classes were where they usually learned about processes and issues related to the natural environment. This is similar to international school students, though the more senior international school students (ages 16-18) reflected that they were also exposed to environmental issues and their impacts on society in their English, Chinese and foreign language and literature classes. The most common topics covered include climate change, waste management, greenhouse gas pollution from industry and agriculture, ocean pollution and the plastics waste problem. More informal opportunities to become aware of environmental issues came from initiatives like teacher-led or student-led environmental, gardening clubs or science clubs, participation in science/environmental problem-solving competitions or conferences, student roles as 'green' classroom monitors or ambassadors, or occasional assemblies with speakers (their teachers or external guests like NGO representatives) highlighting specific environmental issues, often with a local connection.

Students have some similar impressions as their teachers about particular psychological attitudes like response efficacy, that help tackle "helplessness and apathy" to address local and global environmental issues (IS, C, Lang). As Figure 30 shows, there is overall agreement (combining somewhat agree and strongly agree, the two blue colours) with the response efficacy statement, a Margaret Mead quote, "A small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has". A similar result can be seen in Figure 31, where students felt their local actions can still have an effect on the issue at a wider scale. These student viewpoints carry a hopeful and expectant tone that relates with the teachers' outlooks about scaffolding confidence in one's abilities and in realising what actions one can tangibly take.

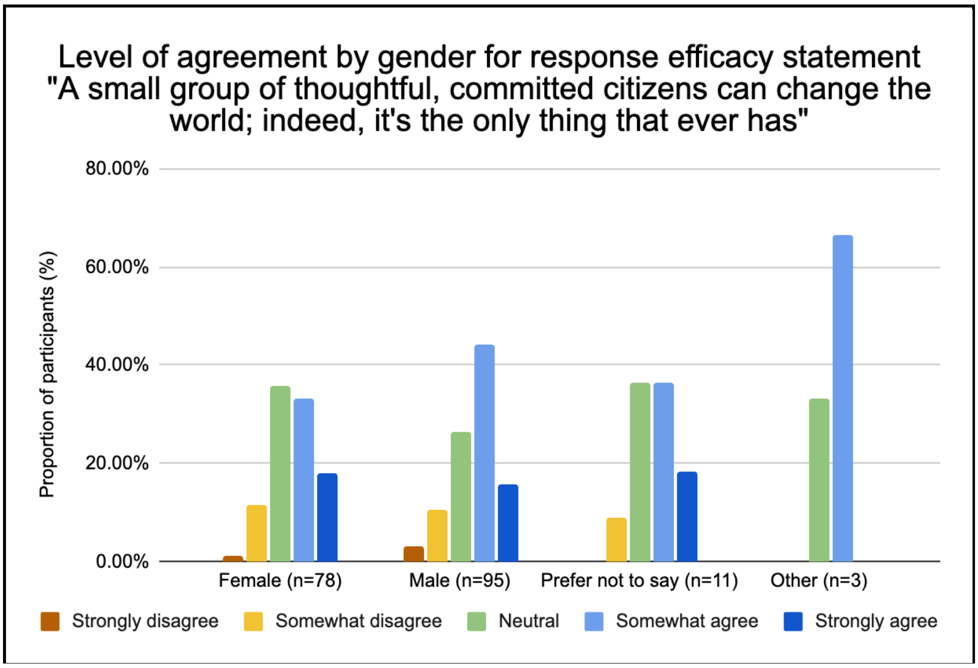


Figure 30: Comparing responses by gender to the Margaret Mead quote that was one of the measurements of response efficacy.

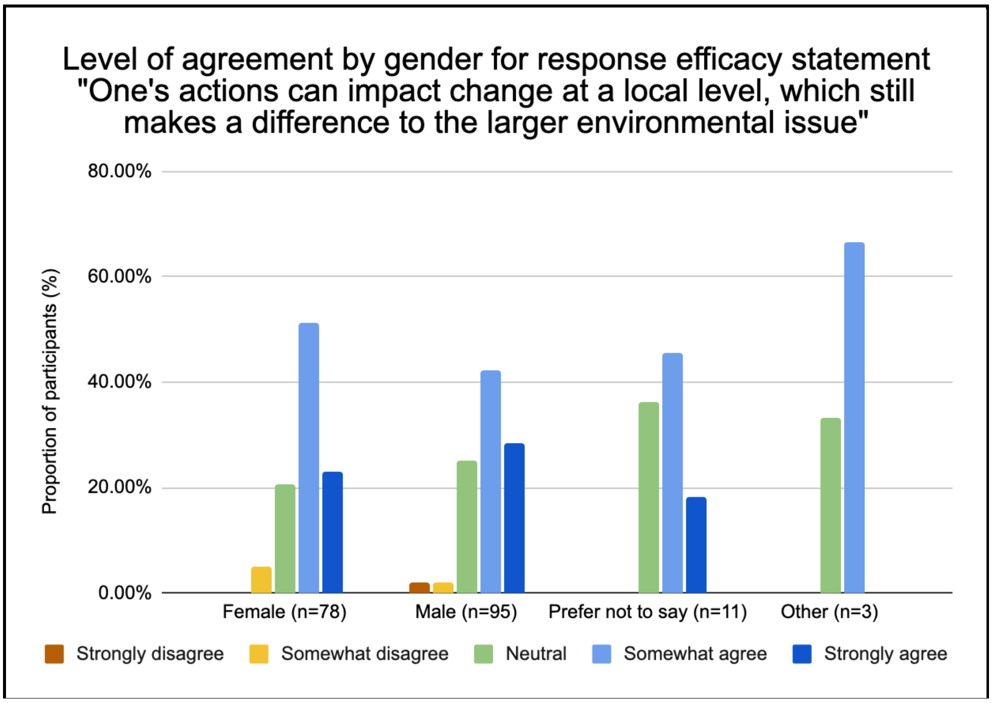


Figure 31: Comparing responses by gender to the statement about one's own actions' impacts, the second of two measurements of response efficacy.

Students from both local and international secondary schools had consistently similar ideas about what the goals of environmental education should be, where they typically learn about issues affecting the natural environment and how they feel impacted by what and how they learn. In the pre-surveys, only 9.1% of local school students said they 'often' or 'very often' have field trips in nature, which is in stark contrast with 49.7% of international school students who expressed the same. A similar trend also was seen regarding school-organised field trips to environmental centres; 18.2% of local school students said these experiences happened 'often' or 'very often', while 31.5% of international school students felt that way. Students mentioned in their interviews that having access to such opportunities was often a result of one's choice of subjects, as the sciences and humanities had the most field trips. Yet, despite these differences, the most common messages the students shared were the importance of using environmental knowledge for action and the value of learning about environmental issues where they occur, as it connects in a more personal manner. The following paragraphs reflect these ideas in more detail using student perspectives and experiences to delve into the main themes, shown in blue ovals in Figure 32.

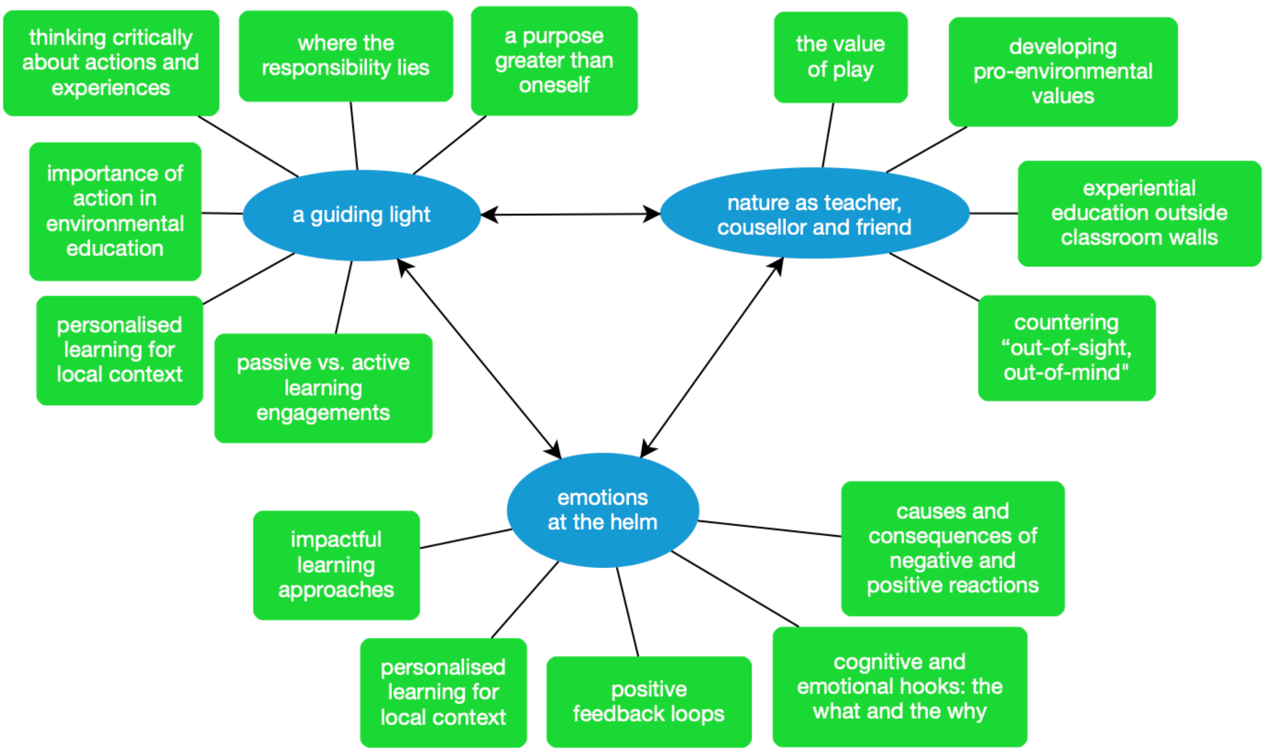


Figure 32: A thematic map of student perspectives about environmental education; themes are in blue ovals, sub-themes are in green rounded boxes, and the lines and arrows show association.

A Guiding Light

This theme expresses what students feel the goals of environmental education should be about. Students across all grades said the utmost important outcome was to apply one's learning towards pro-environmental action. Environmental education has the potential to connect global challenges in local and more personally relevant ways, and by its very nature, the learning can be more experiential, often being active outside the classroom. This active approach can lead to thinking critically about one's learning experiences and how one could go about addressing the environmental issues they are concerned with. This consideration of potential action links to students realistically appreciating the different responsibilities for action. And finally, the content of what students learn holds a deeper meaning as taking pro-environmental action provides a purpose beyond simply studying for academic achievements.

When describing the goals of environmental education, students were quick to point out that "it's good to have some background knowledge" (IS, CS-S, YS, F) about environmental issues, and the best ways to learn about it is through more active learning approaches like going on field trips or being on-site to see the impact of the issue directly. The following exchange between four older international school students during their group interview was typical of the logic explaining the value of experiential environmental education and how it prompts critical thought and self-reflection about action competence towards behavioural change.

> *1: I think first should be to raise awareness, because I mean you can't be educated about something unless you know you're aware of that. It's a problem in the first place, or you know what threats are at the moment, that's another thing. Yeah. And then maybe, you know, practical learning - like going out on field trips and actually seeing, like going to Mai Po marshes or just going down to the beach just here. And, you know, that sort of thing. And actually going outside and not just learning about in theory.*
>
> *2: Especially, maybe a really, really important part that sometimes people don't get in, in their education is just not so much learning about it, but actually doing it so they can, so we can see.*
>
> *3: I agree with that. I feel when you do something, it feels more real than if you were just taught about it in a classroom, like everything else, especially things like the environment. It's even more important to see it yourself. Like we went on a trip called Eco-venture and there was plastic all over the beach and we spent 20 minutes, half an hour collecting plastic and everything. And we came up, like, huge, huge bags of waste, and we wanted to continue but our teachers wouldn't let us, because we had collected too much to put on the boat!*
>
> *4: We literally, there was no space for people!*
>
> *3: We were all reflecting, we were all like "Wow!" That was, that was the moment when I was going to reduce my plastic consumption.*
>
> *2: Yeah, really puts things in perspective.*

Exposure to the issues is vital for the learning to leave a mark as "words don't have that effect" (IS, C, OS, M), as another student shared how educating about such important information using "just pen and paper… is meaningless" (LS, Co, YS, M). They go on to explain how the value of personalising the learning experiences leads to developing such care and concern that doing harm to the environment would be like "sacrificing yourself or like, a loved one, [rather] than, like, a stranger" (LS, Co, YS, M). Their feelings are echoed by a student who felt experiential education had the power to open their eyes to the reality that needed addressing: "if we go to the ocean, we see a lot of plastic and littering. It can also incite us to take action" (IS, C, OS, M).

The significance of environmental issues especially comes into focus when the impact is seen at a local level. Once experienced personally, the understanding of why one should do something to address such issues becomes clearer, sparking ideas for citizenship action. Students suggested that it is more common to be taught about the global scale of the most pressing environmental issues like biodiversity loss, pollution and climate change. A student critiqued that such learning could come at a cost of knowing more about what can be done at the local level, as "we don't often get information of how to, how to contribute effectively on a, on a local scale because we learn of all the conferences like COP25 [and the] Montreal conferences" (IS, Co, OS, M).

With raising one's awareness and considering what are appropriate actions to take being important goals of environmental education, students expressed concerns about the messaging of where the responsibility to take action lies. Hearing that they are the generation of future decision-makers to tackle these local and global threats simultaneously prompts self-reflection and frustration. A student shared that environmental education should help one "understand the consequences of your actions… [such that] the ideal is to… reflect on your, on your actions and act on them" (IS, C, OS, F), while another added that, "I don't think, like, it should be expected that, that we'll, like kind of, like, fix everything… wrong with the environment right now" (IS, C, OS, M). A parallel sentiment was shared by another student who felt that, "we bear a lot of responsibility for taking action, when actually, a lot of us have contributed a lot less to this issue than some of our predecessors" (IS, Co, OS, M).

Despite these reservations, secondary school students asserted that environmental education had a purpose that went beyond curricular needs and academic achievement, but was rather for learning about how to do good by the planet and people. They felt it important to "let the people know what they are doing to the environment, and how to, like, protect it" (LS, C, YS, M), while "spreading awareness, teaching students…how to make it better" was key (IS, C, OS, M). A student (LS, Co, OS, M) expressed the challenge of adhering to such lofty goals:

> *I think the goals of environmental education should be how to reliably and efficiently use the resources we have. Because you know, humans, they definitely need resources, they cannot live without resources. But I think that, like we have to use the resources… [and] we need to be efficient and not be too wasteful. Yeah. And the*

problem, like, the stuff we do, we aren't trying to harm the environment, but there's a lot of collateral damage.

Environmental education can be seen as a guiding light to making sense of the weighty challenges that students learn about and to providing inspiration about potential ways in which to respond. Students highlighted how an experiential approach makes an impression because seeing is believing. With seeing comes reflection; reflections about what actions students intend to take. These ideas are explored further in the following section that shines a light on how students see benefits in their learning and development of environmental values by being in nature.

Nature as Teacher, Counsellor and Friend

This theme captures the idea of how students view the opportunities to engage in environmental education in natural surroundings. 'Nature as teacher' is about how students find being actively engaged in learning outside the classroom more impactful than environmental education in the form of lectures and speeches, which is their usual experience. 'Nature as counsellor' relates to the development of pro-environmental values with increased encounters in natural settings, especially when done regularly and in active ways. It also touches upon countering the 'out of sight, out of mind' mentality by exposing students to the reality of various environmental issues when physically in that environment. 'Nature as friend' is about the importance of playing in nature and learning to overcome fears and developing a connection through that tactile experience.

A student stated that, "it's also very important that we should go into the environment to see what is happening now in those environments" (LS, C, YS, M), as a response to not only the goal of environmental education, but the value of being where the action is. Being and learning in nature contrasts sharply with the more passive educational approaches experienced by local school students, as one student shared that "students in our school, they don't like talks…", and that "seminars, lectures about environmental science… most people just fall asleep, it's not that interesting for most people" (LS, Co, OS, M). Not only are experiences in nature more fun and interactive, but students are often "more engaged when things are, like, hands-on" (IS, C, YS, F). These perspectives link back to the relatively fewer opportunities for field trips in nature that local school students have in comparison to international school students, and reflect a wish for enhanced experiences in the way they are taught about the issues affecting the natural environment. Such engagements are useful for countering the problem of 'out-of-sight, out-of-mind' especially if students can have regular excursions in nature. A student, who has easy access to the coast adjacent to their school campus, shares that during beach clean-ups, "you see, like, there's a lot of, like, trash produced, so you, like, have to realise that, like, things don't just disappear… they still like, exist… in the seas… in landfills [and] they're still pretty harmful to the environment" (IS, C, OS, F)

Students especially those from international schools, shared how time in nature develops their environmental values and perceptions about nature, and nurtures their personal well-being. The more that students described spending time in nature, the more they claimed to be passionate about experiencing and caring for its biodiversity. A student reflected that "when I go out in nature, it just feels like I'm a part of the nature. It's kind of peaceful and refreshing [to] not have my face in front of a screen for the whole day" (IS, C, YS, F), as Covid-19 related school closures led to online learning and intensified computer screen exposure. One of their classmates said that they conquered their hesitancy to explore particular natural spaces near their home by learning about the ecosystem and venturing into nature on a regular basis: "I started… going up there (a bamboo forest near their village), seeing what there was… [but] before I was like, oh, no, that's dangerous, like, don't go near it" (IS, C, YS, M). Students with limited access to natural environments made use of suburban parks as venues to play in nature with friends by taking walks and climbing trees, reminiscing how "it was a big part of my childhood". The reality for a student (IS, C, OS, F) who grew up in Hong Kong depicts a somewhat conflicted relationship with nature:

> *Like, I'm a typical Hong Kong kid. So my childhood is: I did homework, I went to school. But sometime my parents bring me to the beach, after school. Yeah, last year is like a chance for me to like get in touch with nature more because I went to Austria. There were lots of nice mountains and so we went hiking a lot, and then also at a lake. Yeah, that's something that made me feel like I love nature, but not Hong Kong. Everywhere is like, there is rubbish in the beach and the water is polluted that like, last time we went diving in Sai Kung, for coral monitoring… we can't actually see things in the water because the water was so dirty. My parents asked me "how was your dive?" and I said, "if we put some mud into the water and stir it, that's what I see!"*

The different roles that nature can play connects to the deep impact such experiences have on students cognitively and emotionally, a theme that is further explored in the following section.

Emotions at the Helm

This theme centres around the notion that students build emotional connections to environmental education that is locally and personally relevant. Though environmental information and data can be insightful, multimedia representations of the same information are more powerful, cognitively and emotionally. A student reported that, "when you watch documentaries and see animals dying, you feel sad and some people actually cry, so that it makes them more motivated to make a change" (IS, C, OS, M). Further, learning by being in-situ is an even more impactful way to link content to its significance which triggers reactions and feelings of concern, shock and/or motivation. Subsequently, actions taken to respond to the environmental challenges reinforce the learning-by-doing feedback loop in a way that counters environmental anxiety. Students proposed the idea that the more they are involved in pro-environmental actions, the more they are encouraged to continue contributing, as it taps into knowing that what they are doing is right and good.

During the interviews, a common thread in student responses was how their learning about environmental issues was enhanced the more time they spent in natural environments and in places where the problems could be tangibly seen. Additionally, when students were provided with learning opportunities beyond reading texts and listening to lectures, such as viewing visuals and documentaries, they often spoke of having strong emotional reactions that lingered with them. The famous image of the turtle with a plastic straw in a nostril was specifically highlighted by multiple students as an unforgettable visual that disturbed them and prompted concern.

> *When I see something bad happening to animals because of the environment, it's so sad, because I clearly like animals, because I have a lot of pets. And I just, I feel, I feel bad for the turtles, and the dolphins and other creatures, and it makes me want to help them.*

Feelings of sorrow, as described by the student above (IS, C, YS, F), and distress were noted in their responses to not only seeing the impact of environmental problems on their screens, but even more so when they saw it with their own eyes. Physically having access to the realities of environmental issues which students get exposed to during classroom lessons sets cognitive and emotional hooks. A student (LS, Co, OS, M) reflected that:

> *Listening is just absorbing information from the tutors [teachers]. Different. But when you sit by yourself at the beach, you're interacting with the environment. So I don't know. So maybe, see by yourself is more, will make you more shocked. When I see the plastic on the beach by myself, I'm also horrified.*

The student's sentiments echo the significance of localising and personalising the context for their learning, so when they discuss the global marine plastic pollution, they not only learn about the 'Great Pacific Garbage Patch' but also the local manifestation of the issue. The scale of the problems can be "intimidating because you're like, wow, this is getting out of hand. Can we please do something about this, like, now, so we don't die?" (IS, C, OS, F). Though this anxious message reflects frustration, there is also a call for responding with action. Taking action creates a positive feedback loop of satisfaction, purposefulness and determination that confronts such feelings of anxiety and paralysis about addressing the looming environmental problems.

It just makes me feel like I've done something for the environment to make it better. It's a good feeling. (IS, C, YS, F)

Raising awareness is good. That's one of the best things to do. But taking action might be better. Because if some people don't want to, well, then you're not just gonna sit there and just wait, you have to do something yourself. Right? … It'll make you feel good, you know, like, about what you're doing, 'cause you're helping in some way. (IS, C, YS, F)

It should be noted that some of the positive student reactions about engaging in this type of outside-the-classroom activity could stem from the fact that, due to Covid-19 restrictions at the time, field trips had generally been cancelled and students had already spent the school year in online or blended learning with large amounts of screen time. However, even under normal circumstances (in school years prior to Covid-19), there is a discrepancy in access to nature-based field trips: in pre-surveys, only 9.1% of local school students reported they often or very frequently have such school-organised opportunities, whereas 49.7% of international school students felt that way. This five-fold difference about commonly having occasions for nature-related experiential education is an important finding considering the results from the previous chapter regarding variables that influence behaviour, specifically personal experiences in nature (see Ch. 5.5.2).

Impressions shared by different international school students show the power of emotions in developing understanding and the impetus to apply their learning to respond in an empowered way. These ideas are developed further in the next chapter, where students shared their opinions about citizenship action.

6.1.3 Citizen Science Organiser Perspectives

The four citizen science organisers interviewed all spoke of the significant role that education plays in developing greater environmental literacy within society. The citizen science organisers felt that the value of environmental education lay in its capacity to entice those who may not normally engage in the topic with hands-on learning, often in natural surroundings. They described the ultimate goal of such learning experiences was to develop pro-environmental values and a concern for nature. These ideas are captured in the theme 'preaching beyond the choir' (see thematic map, Fig. 32). There was an acknowledgment that decades of learning about various environmental issues in schools have led to raised awareness levels, but the citizen science organisers suggested more could be done to address the environmental urgency being faced. These feelings are represented in the theme 'aiming for the stars' (see Figure 33).

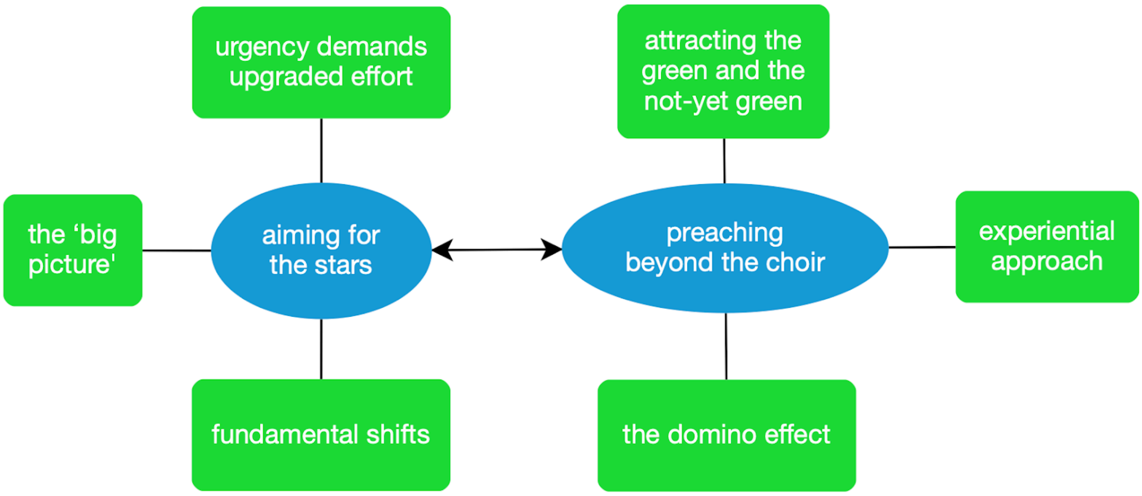


Figure 33: A thematic map of citizen science organisers' perspectives about environmental education; themes are in blue ovals, sub-themes are in green rounded boxes, and the lines and arrows show association

Preaching Beyond the Choir

> *I hate to be crude, but I couldn't care about the environment. I was just like, okay it's nice, it's nice if I do something nice for the environment, but it's not like I'm going to go out of my way. Then I think, a couple of things happened: I travelled a bit, I went to the Philippines, I saw, literally, the corals dying, I went to Indonesia, I saw the corals dying, so I'm like, it makes sense. So when I saw the damage for the first time, that is when I realised the size of the problem, and I thought okay, I'm in a position to actually do something about this, right? So, I think, yes, the more I engaged with it, the more I am convinced that this is something important and the more I'm able to spread that message out to other people.*

This anecdote was shared by one of the citizen science organisers (S-U, Co)) who supported a school in their co-created citizen science project to address marine plastic pollution. In their capacity as the founder of an environmental start-up, they have supported a number of students who have expressed an interest in their expertise. Yet, as they alluded to, this green mindset was not there to begin with, and it took being physically present to see ecosystem damage and biodiversity loss to spark a shift in perspective and prompt action. Having reflected on their personal transformation (see quote above), they supported environmental education being increasingly hands-on and experiential. Another citizen science organiser, who developed and led the HKISCNC which five of the eight schools participated in, agreed that experiences where one can gain an appreciation for nature creates a "domino effect… you're not going to care about something if you don't know much about it" (NGO, C). They also suggested that experiential environmental education is a way to counter the often-heard question from students: "when am I ever going to need to do this in real life?" (NGO, C).

Another citizen science organiser, who volunteered with the NGO that organises the HKISCNC and presented the project to local school students, felt that teachers, as much as students, could benefit from exposure to a more experiential approach to learning about environmental issues. They noticed a few teachers who likely had their classes participate in the HKISCNC because "the school asked them to… you can tell from their face" (NGO, C). Yet, during the same excursion they witnessed a number of teachers were just as excited about the species observed on campus as their students were. During one interaction with students observing butterflies flying in a small grassy space, a teacher passing by the area remarked, "Oh! I didn't notice about it [the presence of butterflies]! How come I go in and out of this classroom every day and I don't notice about it?!" (NGO, C). This reveals how teachers who may not necessarily be involved in environmental education could still be attracted to engaging in the topic if given the opportunity.

Aiming for the Stars

Environmental education that incorporates being where the issues are is a powerful way to learn, as shared earlier by a citizen science organiser. However, that organiser felt that students should also be taught about environmental processes and issues more holistically because "they know that there is trash, but they don't know why it matters… They [students] reach out [to us] but they don't completely understand why any of this makes sense" (S-U, Co).

With greater urgency to respond to the many pressing environmental issues, citizen science organisers felt motivated to deliver formal and informal environmental education to Hong Kong students to support a "fundamental shift" (S-U, Co) in learning about and responding to the threats. Based on interactions and questions posed by students, this citizen science organiser (S-U, Co) thought:

> *schools, they teach recycling, they teach you the individual parts of the story, but they don't connect them up in a very nice way, so that is something that is missing… the big-picture context… I think that is something in the education system we could do better. It kind of ties in to citizen science actually.*

In subsection 6.2.3, I delve deeper into their area of expertise and relay their perspectives about the value of and gains from nature-based citizen science experiences.

6.2 Citizen Science

This section is focused on what teachers, students and citizen science organisers thought about their citizen science experiences. The following sub-sections reflect themes that articulate their perceptions about the value of and gains from their respective citizen science activities, as well as how such experiences could be enhanced for greater impact. I start by sharing the thoughts of teachers, then students and then the citizen science organisers. Some key themes describe how various participants saw: (i) the value of a citizen science approach in making learning about environmental topics and issues more engaging; (ii) how conducting real world research adds a different purpose and dimension to school-based learning; (iii) where teachers could also use the opportunity to enhance their own profession development journey. The final sub-section (6.2.4) compares their points of view to highlight shared and differing ideas.

6.2.1 Teacher Perspectives

In the semi-structured interviews with the 18 local and international school teachers, I posed questions about their experiences incorporating the citizen science projects into lessons and any perceived impacts on students. Teachers also reflected on how these citizen science experiences influenced their own pedagogical approaches to environmental and experiential education. Though the majority of teachers had no prior experience incorporating citizen science in their lessons, five of the eight participating schools had no prior citizen science experience (see Table 16), they remarked at its ability to bridge the gap between scientific theory and scientific application. Framing the learning about environmental topics like biodiversity and pollution with the need for contributing to research provided a worthwhile purpose, extending beyond what the curriculum offered. Teachers could see the potential for citizen science activities to develop not only knowledge and skills, but also an excitement about engaging in science in general, with student-centred inquiry. Alongside these positive impressions, there were messages of caution. Some teachers expressed concern that the role students play in contributory citizen science projects may bridle their capacity to contribute in more diverse and complex ways. Another focused on managing the sustainability of citizen science initiatives at schools with multiple demands on their staff. Overall, the teacher responses about citizen science were categorised into four themes with associated sub-themes: (i) From theory to reality; (ii) Pedagogy with purpose; (iii) Students at the centre; and (iv) Keeping the momentum going (see Figure 34).

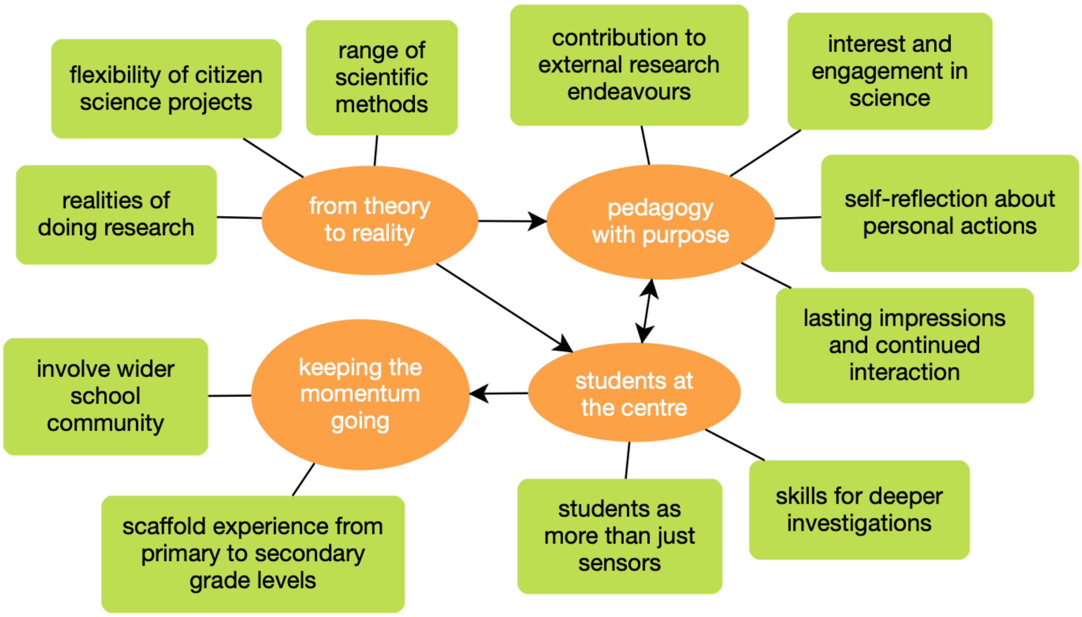


Figure 34: A thematic map of teacher perspectives about citizen science; themes are in orange ovals, sub-themes are in green rounded boxes, and the lines and arrows show association.

From Theory to Reality

> *It's difficult when you just study something at school, and it's all theory, and then you don't really know how it applies to real life. It happened to us when we were going to school… like we were just like studying, but then we didn't really see how what we were studying applied to real life. So doing citizen science, I think it allows the students to make that connection.*

A recurring notion, exemplified by the quote from a teacher above (IS, C, Sci), about the value of citizen science was how it could be used as a tool to connect more abstract scientific information to ideas one could tangibly engage with. One teacher considered citizen science as a "good tool to take something from the textbook into reality" (LS, C, Sci). They likened it to an "animated textbook" and found it a "really good tool for me for teaching". Just as environmental education was seen as a powerful lens to learn about the application of science in real world contexts (see earlier subsection 6.1.1 about environmental education under the theme, 'Making the impersonal, personal'), citizen science can play a similar role as a hands-on mechanism to link theory to reality.

Part of the attractiveness about the citizen science approach is the use of technology. Teachers observed students being more engaged in the activity because of the use of, for example, the smartphone 'iNaturalist' app (for those who participated in the HKISCNC), drone photography and AI programming (for those investigating coastal plastic pollution), and online citizen science platforms (for those supporting air pollution research). A teacher involved in a co-created citizen science project said how "students like the technology… so that's why I hope to engage them in an interesting way. And then when I think of the drone and I think using the AI" (LS, Co, Sci).

Other benefits teachers saw in citizen science as a pedagogical tool were (i) the range of available projects to suit a variety of learning objectives within environmental education curricula, (ii) the options of project modes from online-only to field-based projects, and (iii) the flexibility to engage in projects to differing intensities based on lesson opportunities and constraints.

This flexibility meant that some students ventured outside their classrooms for as little as 30 minutes to contribute to biodiversity observations (during the HKISCNC), while teachers who opted for a more intensive and longer-term citizen science experience had their students travel 40km from their school campuses to conduct marine ecology and plastic pollution investigations for intensive multi-day experiences or regularly for many weeks during the school year. Citizen science is seen as an adaptable, structured and 'ready-to-use' approach to incorporate experiential education into student learning.

The learning also goes beyond content because scientific research involves a range of skills such as observation, measurement and problem-solving. A teacher commented that adding a citizen science approach to their geography investigation into marine ecology and pollution enabled students to experience various methodologies for data collection beyond what they typically would have done. In addition, the very process of following an established data collection approach that required great effort impacted students' perception of how research happens.

> *The repetitive nature of actually carrying out your fieldwork… it changes your perspective. Because now when we're looking in class about a study that's done, they just don't see face-value, as a piece of paper, and a study, and I just need to read that this scientist did this. They now know the amount of work that must have gone into making a conclusion, and then that conclusion must be valid… that was good for them to experience.*

In this case, the teacher (IS, Co, Geo) reported that these students' experiences with citizen science prompted critical thinking about evaluating research quality and the significance of the findings. These types of skills are a way to take the more theoretical elements of research and science and link them to experiences students understand and can relate to.

Pedagogy with Purpose

This theme is an extension of the previous 'From theory to reality' theme because it hooks purpose to the learning that happens during citizen science experiences. From the teachers' perspectives, purpose is represented by student engagement and contribution to scientific research endeavours. It is also exemplified by the impact on students in the forms of lasting impressions and reflections about how to apply what they have learned.

Citizen science is different from many other experiential activities given the collective nature of how enquiry and research is being carried out. Despite challenges of conducting more extensive fieldwork for a collaborative citizen science project, a teacher proposed that when students do such investigative work to fulfil curriculum requirements "there's no reason why they can't have their data used for another purpose" (IS, Co, Geo). Their colleague agreed that "even if they were doing, like, a pilot study… [the students] could see why somebody [scientists] would potentially do it on a larger scale" and the citizen science context "gives the data value" (IS, Co, Geo).

Another teacher (IS, C, Sci) spoke of the role of an individual in the wider context of how one can contribute, be it in citizen science or towards pro-environmental action:

> *Citizen science really requires their [student] involvement and realizing that you're part of a bigger picture. And I feel like that, that's also… the themes in environmental education as well, and so I think both from, like, a sort of philosophical standpoint, in terms of your part of the bigger picture and [how] you can contribute to something… this sort of global collaboration… I feel inspired by that and I feel like that would make students also.*

The teachers projected that students could see the value of "helping other scientists" as a way of "helping others… for a good cause" (IS, C, Sci). Another teacher felt that citizen science experiences like the HKISCNC connects with students' general interest in nature and it "breaks down that wall… like science can be done by anyone" (IS, C, Sci). They expressed how "citizen science has made it easier for me to teach" because it is a form of enquiry that is more "accessible for kids and students, and even teachers that are scared by science":

> *The scientific method, just like, even that word, sometimes, kids are scared, like, 'oh, the scientific method', but like, you're just predicting what you think will happen and then seeing what happens. So, you know, [citizen science] makes it [science] more approachable and easy.*

Their colleague felt that "using citizen science for students gives them more power in their education" and supports greater engagement in scientific investigations and activities (IS, C, Sci). Local school teachers, who had students participating in the HKISCNC, noted how using 'iNaturalist' helped to "arouse their awareness… to let them pay more attention to the surroundings [the biodiversity on their school campus]" (LS, C, Sci). Their colleague observed how engaged students were as they got "involved by taking their own picture… like to take something interesting which keeps motivating them to continue to keep doing this [observing and logging biodiversity]" (LS, C, Sci). Their colleague remembered how their "students were very enthusiastic, they walk around or even run around to search for plants or even animals" (LS, C, Sci). In the days and weeks that followed the HKISCNC citizen science experience, teachers noticed how some students continued to make observations on their own time and outside of their school campus to "see what's around and they like to look at that and the analysis is interesting" (IS, C, Sci) These responses seem to reflect that student interest and engagement in citizen science can go beyond educational expectations, at least for a little while after the initial school-based activity. This also points to the important role that teachers (and the experts involved in ''iNaturalist'') play in helping maintain interest, as students enjoy getting feedback about their biodiversity observations.

A teacher (LS, Co, Sci), leading a project about marine plastic pollution, saw how their students reflected on their learning and developed pro-environmental (project related) habits as a result, such as sorting plastic waste and reducing plastic consumption.

> *I think for this project, I can see that… from the beginning… they [students] do not know anything… they may not be very aware of the problem. But at this moment, I think they are very sensitive… I see that they take the… initiative to take the action.*

This observation anecdotally supports the overall finding I reported (see earlier Ch. 5.3.3) of a statistically significant increase in self-reported pro-environmental behaviours in student post-surveys. I also share the students' perspectives about the impact of this particular citizen science project on their behaviours in the next section (see 6.2.2).

Students at the Centre

With their experiences of contributory, collaborative and co-created citizen science projects, the teachers reflected on what could make citizen science initiatives more effective for learning. This theme captures the idea of developing citizen science experiences by keeping the learner's needs at the heart of its design and implementation. Teachers acknowledged the potential of a citizen science approach for curricular investigations and suggested students can be involved in more meaningful ways than simply being observers and recorders of information.

Teachers believed that students would gain from having citizen science projects cater to their interests on a range of levels. As mentioned earlier, teachers appreciated the low barrier to entry in projects like the HKISCNC to record biodiversity using the ''iNaturalist'' platform. This taps into student interest in flora and fauna in an accessible and relatable way. However, one teacher, who had prior citizen science experience, felt that "most of the time… we treat our student just like a sensor, go to surrounding[s] and just take a photo, and you observe" (LS, C, Sci). They believed that students could be more and do more, scientifically:

It may be better if we can show how to make better use of the data, for example, the certain species on the globe, and showing them about the time, how does it grow, which season or how does the migration… it takes… more data science skills.

Going beyond using students for their eyes and ears to detect species, the teachers proposed using the data output as an enquiry springboard. They thought it would motivate students to participate in deeper investigations aligned within their curriculum, by asking their own questions and analysing the data that they and others have collected, for their knowledge and skill-building.

Another benefit for students would be to address how they experience a school-based citizen science project. Rather than having it as an add-on activity, it would be better for student learning to have this experiential approach be embedded into the lesson. This not only clarifies the context for the learning, but it also aids in citizen science project longevity by establishing its use in pedagogical documentation for other teachers to follow in the future.

Keeping the Momentum Going

This theme continues from the previous "students at the centre" theme as it offers thoughts about improving students' experiences of citizen science initiatives from a logistical point of view. The factors of time, collegial and wider community support are commonly raised.

Teachers commented that those who are responsible for more experiential learning get selected to implement citizen science initiatives like the HKISCNC. This means it can often be the same few teachers in charge of driving such projects forward, limiting the knowledge and uptake of this pedagogical tool in other learning settings by more staff. A teacher hoped by making it "a Green Team committee initiative… having a group of teachers that are in charge, I feel like it'll run more smoothly, and there'll be more, more participation" (IS, C, Sci). They also felt that if it was just them and their colleague "squawking" to their colleagues to "do this, do this, do this" [multiple citizen science projects], they would not garner a lot of help for collaboration.

Another aspect to develop the use of the citizen science approach in teaching and learning is to introduce this experiential enquiry tool to younger grade levels. A teacher thought "we can get more citizen science opportunities in lower school as well as the upper school" and these experiences could be "encouraging the right behaviours and attitudes" towards the natural environment (IS, Co, Geo).

A motivational way to maintain engagement in the citizen science project is to increase the quality and quantity of interaction between the learner and the expert. Teachers reflected on how their own use of a platform like 'iNaturalist' would wane after some time because of limited feedback from biodiversity experts beyond a possible species identification status. One teacher (LS, C, Sci) critiqued how after some time recording biodiversity with the 'iNaturalist' app:

> *I won't use the app anymore. So, I think in that case, maybe, the app or this organisation [that runs the app] can give us notification or feedback, for example, after find out something interesting or that something is happening, for example, there is certain days that they find out that many animal may appear in that location, maybe if I receive this kind of message, it can increase my chance to use the app again. So that means it's not only a single direction to provide the data, but might be in reverse, the app can… show us some information, to encourage me to do more or show me more information, then in this case… it's a long term run that we can use this app.*

Their colleague who had limited prior experience with the 'iNaturalist' app and the HKISCNC citizen science project agreed and wished for more regular and personally-relevant interaction, otherwise the "usage is more, like, short-term" (LS, C, Sci). Another colleague was concerned that if the teachers felt this way, so would the students, hence the importance of asking "how can you attract, or how can you allow the students… to continue this kind of practice?" (LS, C, Sci).

6.2.2 Student Perspectives

This subsection explores what students valued about their citizen science experiences, what they felt they had gained and in what ways such activities could be enhanced for greater impact on knowledge and skill development. As shown in Table 16, 59.9% of students had no prior citizen science experience, and in Figure 15, 59.3% had an incomplete understanding of its definition. Thus, in their eyes, this was a novel and "a very unique way to learn" about science and environmental issues at a local scale (LS, C, YS, M).

Nature-based citizen science projects, using the 'iNaturalist' app or the 'CoastalWatch' methodology, were experiences valued as highly as field trips and experiential environmental education activities. Students also appreciated how being involved in contributory or co-created citizen science projects provided an additional purpose to their learning that supported wider scientific investigations in biodiversity, and marine and terrestrial pollution. Most of the students (90.4%) participated in one-time citizen science projects that lasted between 30 to 80 minutes (see Table 16), and these opportunities were seen in such positive light that they desired greater scope for the activity and follow-up reflections. These overall ideas are reflected in the themes (orange ovals) shown on the following thematic map (see Figure 35) and discussed in more detail with student quotes.

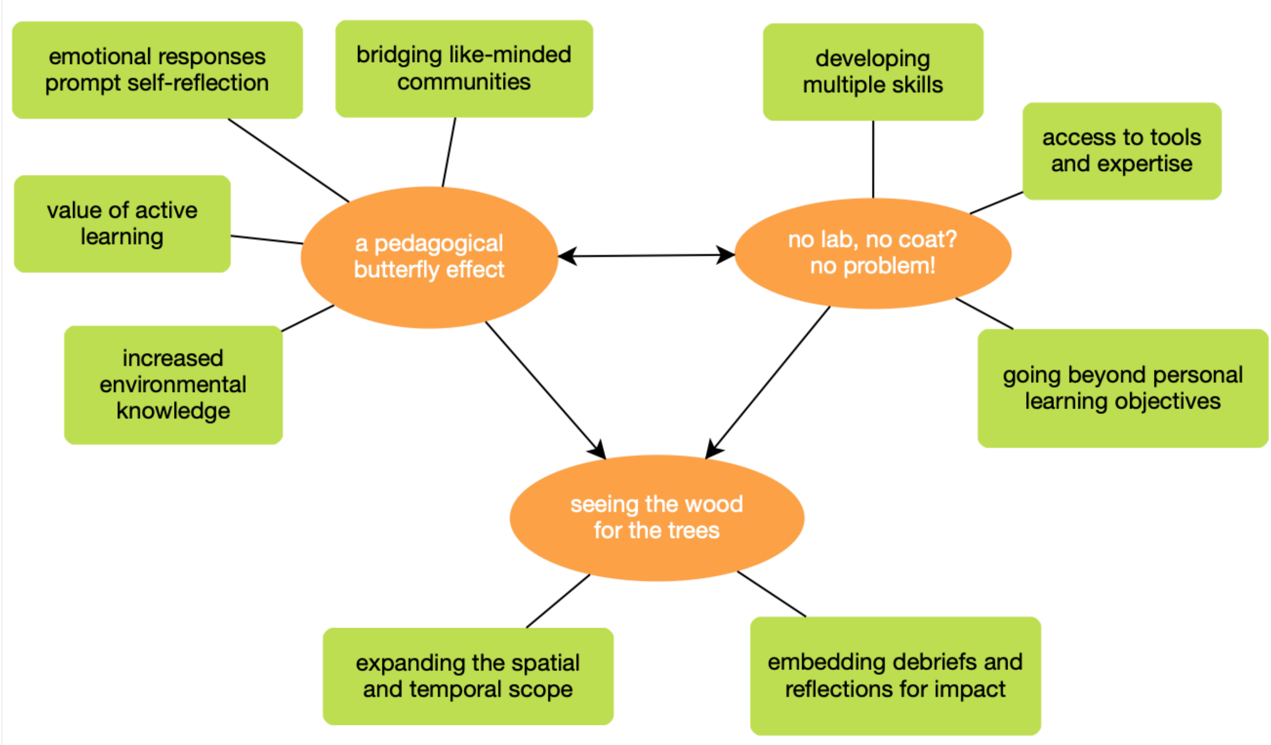


Figure 35: A thematic map of student perspectives about citizen science; themes are in orange ovals, sub-themes are in green rounded boxes, and the lines and arrows show association.

A Pedagogical Butterfly Effect

This theme encapsulates the notion of how powerful an experiential approach like citizen science can be in affecting how and what students learn, and what actions could result from their reflections. As highlighted in earlier themes for student perspectives about environmental education as a whole, citizen science is a specific and active way to learn about environmental topics and issues, which also seems to support increased knowledge acquisition. Just like was expressed with the 'emotions at the helm' theme in section 6.1.2, engaging in nature-based citizen science activities, especially outside the classroom, creates opportunities for students to connect to their learning with emotions. These emotional responses prompt self-reflection about one's own role in the environmental issue being explored. Subsequent thoughts about potential pro-environmental actions and recognizing that citizen science projects are built around a community of people who are interested in the topic, encourages continued participation.

All the students described their respective citizen science activities as worthwhile experiences. One local school student, who participated in the HKISCNC, reflected that "we can find them [biodiversity] ourselves. But not looking at them at the textbook, but really go into [nature] and see them. And I think it's very interesting" (LS, C, YS, M). Their classmate (LS, C, YS, M) agreed and distinguished their citizen science experience as a more compelling way to learn than other types of environmental education activities they were more familiar with:

Look at your phone. "Oh, there I have [the 'iNaturalist'] app and let us see!" You can see, maybe about the plants and then maybe you Google about… something about the plants, of the characteristic of that, or go to school for ask the teachers. Is more effective than some of these activities of just visiting something [a museum or science centre], or have some people talk to us.

Gains in environmental knowledge after the citizen science experience as shown from pre- and post-survey results (see Ch. 5.4), were also alluded to during interviews. Students described a greater understanding of ecosystems, roles of flora and fauna in different habitats, and various anthropogenic causes and consequences. One student (IS, C, OS, M), who also used the 'iNaturalist' app to record species observations, relayed how their experience with citizen science influenced their appreciation for the services nature provides:

It made me think that biodiversity is a bit more important too, because since having, having more biodiversity, each organism provides different benefits… for example, bees pollinate flowers, bees pollinate plants. And then I think some flowers have pollen that gets blown by the wind. And then like, for example, mushroom… mushrooms... they release their spores into the air, then people use it to eat. More biodiversity means more opportunities.

Developing this understanding also connected to feelings to preserve nature and consider what could be done about the environmental threats. As a student shared, by "using the 'iNaturalist', taking the photo… and I can also learn about… how is the animal or plant being in danger. And, and, and how to protect the environment more" (LS, C, YS, M). Another student revealed how using the 'iNaturalist' app "actually influenced me to take action because… I've got so many things that I don't know actually. This gives me a feeling that I want to know more… what I can I find more in the wild" (LS, C, YS, M). The student described using the 'iNaturalist' app on personal explorations of their neighbourhood and encouraging neighbours not to pick the wildflowers there. Additional actions they took as a result of their citizen science experiences, included refusing plastic bags when shopping and doing more household waste recycling. Other students felt that their surprise at the scale of the plastic pollution problem during their citizen science project field trips to trash-strewn beaches influenced them to critically reconsider their own behaviours. One particular school student stated they "avoided using plastic bottles because of this project. And also, I think… more about this, this pollution problem, because… before I joined this project…I wasn't as attentive as I was now" (LS, Co, OS, M). I analyse student perceptions about citizenship action at greater depth in the next chapter (see Ch. 7.2.2).

These student responses suggest that there are knock-on effects of citizen science experiences on one's knowledge, environmental values and behaviour. The additional benefit that students saw in this approach was how they became part of an informal group with common interest in biodiversity, as "it brings, like, the community together" (IS, C, YS, M). A student remarked how their one-time experience using the ‘iNaturalist’ app for the HKISCNC led to gathering "our friends and classmates together… walk in Hong Kong, or we see the flowers, butterflies, or some flies and animals and we've said, Oh, we should take a picture for it. Or just send photo to our science teachers" (LS, C, YS, M).

These sentiments link to the next theme about how participating in citizen science helps students feel like they are doing more than simply contributing to science, rather that they are behaving like scientists themselves.

No Lab, No Coat? No Problem!

This theme is about how students felt they acted like scientists exploring an issue as they engaged in citizen science activities. By the very nature of many citizen science projects' public engagement approach, students recognised their contributions were part of a larger investigation that went beyond their personal learning objectives. With most students' experiences of citizen science about observing and recording biodiversity and/or measuring coastal pollution, multiple scientific skills were developed. These included making observations and thinking critically about how to carry out investigations in scientifically rigorous ways. Some students also had the opportunity to use additional tools such as tweezers, magnifying jars, cameras and measuring tapes to name a few instruments, making them feel like real scientists involved in real research.

A key component of citizen science is the need for wider community participation to investigate an issue based on questions posed and methods designed by experts in the field, and, for collaborative or co-created projects, with community members themselves. This circumstance was communicated to all the students prior to them participating in their respective citizen science projects and some students mentioned this as an added benefit to their engagement because the purpose went beyond just their own learning. For the projects using the ‘iNaturalist’ app to make biodiversity observations, students felt it was their added responsibility "to help record it for scientists" (IS, C, OS, F). Another student offered that participating in citizen science was "really helpful for if you want to make an impact on the world… doing investigations and research like this is more effective than, you know, just sitting there and doing absolutely nothing" (LS, Co, OS, M). This sentiment shows how even participating in a citizen science project is a way to take part in a form of citizenship action.

Students explained that another benefit of the citizen science experience was the development of different skills. "When we find some new species," a local student reflected, "I'll be a bit curious and go on and search about that species. And we'll see… things that are happening, so we can have a greater awareness of the environment" (LS, C, YS, M). Students reported feeling intrigued by their observations to independently explore further by doing research and increasing their knowledge. For the cases where students were involved in multi-day citizen science projects (9.6% of student participants), they described needing to ask questions, seek answers, think and adapt quickly to problems arising during the field work, and collaborate with their peers to effectively collect data and complete the many stages in their projects. One student (IS, Co, OS, M) shared their process conducting group research and fieldwork about their co-created citizen science coastal ecology and marine pollution:

> *Doing the research beforehand, definitely improved, well.. my research skills because I, well, we got access… different resources… older articles on the internet, and then some of the new ones… the research that definitely broadened my understanding. But then on the day [of the fieldwork]... we had to do some vigorous planning. And then not everything went to plan, but then I think a skill that I developed was just being able to overcome it… You saw the big paper booklets that we had. Some of the, some of the tables were a bit… [the tables] required modification that we initially hadn't thought about. So it required quick thinking and yeah, teamwork to complete.*

Another student (LS, Co, OS, M), who was part of a year-long project investigating marine plastic pollution added how working as a team had its challenges and how the whole citizen science experience strengthened how they communicated:

> *I think, for me, the communication skills is, like, I've improved the most, because we need to collaborate with, like, the whole team. And then we have meetings online [online schooling due to Covid-19 impacts], which I'm not so able to communicate with them. So… it's hard to coordinate with all the teammates, because we're not, we don't have a meeting at school, for example. So a lot of things, the response is slow, and then sometimes the people don't respond to... yeah, my text messages and to schedule a meeting is also very hard… So I guess there's a lot of problems involving communication. So I think that is the part where I think I learned the most.*

During field observations of a local and an international school participating in the HKISCNC project, students were keen to borrow equipment to better observe and record biodiversity seen in and around their campuses. After instructions and tips on how to use tools like tweezers, plastic bottles and jars with magnifying lids, students were keen to "put it [a mangrove crab] in, like, a bottle and then take it out carefully like that" (IS, C, OS, F). Though a few students felt uncertain about the quality of their contributions as they said they did not have access to professional science labs and machines, they were enthused to share their simple instruments amongst classmates to immerse themselves in the exploratory experience, like scientists would.

Seeing the Wood for the Trees

This theme expands on positive impressions about the value and gains from students' citizen science experiences and suggests how such learning activities could be even more impactful, especially if put into a relatable context. The feedback from students included practical enhancements like providing more time and more varied natural environments to explore that linked to their sense of place. A common request, regardless of the kind of citizen science project, was to scaffold time and space for debriefs and reflections about the learning experiences. This would allow students to put the classroom-based education in context with their citizen science learning. Without genuine links between the two ways of learning about environmental topics and issues, students felt they missed an opportunity for impactful learning they could personally relate with.

As most students participated in short one-day experiences with the HKISCNC citizen science initiative, they desired more time and varied places to investigate biodiversity to supplement their learning. One student (IS, C, OS, F) offered:

> *Maybe we could have, like, explored more than one area to see how it's different in different places? Because, like, I guess, I have now become more familiar with mangroves, but not other areas… it would be, like, more interesting to see different habitats because you could, like, compare them.*

Students considered the lack of an authentic learning context as a limitation of 'pop-up' one-time citizen science projects. A schoolmate expanded on the idea with the suggestion of more time, "like, a couple of days, like a citizenship week type thing" to allow for greater learning opportunities using "themed activities" in order to "actually, like, try to learn about the, like, ecosystem around us" (IS, C, OS, F). Having a more embedded and multi-day project within their curriculum allowed students to develop their own research questions that resonated personally, reflecting how (IS, Co, OS, M):

> *before the experiment, I was thinking of how we going to sample biodiversity… I was thinking about… if we could measure the toxins inside of fish, it would not only show how biodiversity is being threatened, but then for us humans as well, we could see how our actions are coming back to haunt us almost because we're eating these fish.*

Local and international school students alike, shared how there was minimal to no post-activity reflections upon returning to their classrooms, whether in the remaining class period or the following lessons. Due to limited time in the lesson, a student reported, "we didn't really discuss what we saw" (LS, C, YS, M). Proposals such as "activities such as some Q&A sections or something matching about different species name or different characteristic… can lead us to study more,... [we can do] more than just take photos" (LS, C, YS, M) revealed how students want to be engaged in deeper ways to complement their learning. If projects were embedded in curricula such that students know how "this action that I'm doing may impact this species in this way" (IS, C, OS, F) or by "linking it [the citizen science project] more to the way that we live and saying how we affect the species and how they're important to us" (IS, C, OS, M), then students felt their citizen science experiences would have a greater impact. Students linked contextualised learning with the potential to influence behaviours, saying that though "it's good to know that this is whatever type of species that is… it doesn't really say how that's relevant to what we do and how that applies to our lives" (IS, C, OS, M) and since "I'm only taking pictures of, like, animals… it doesn't relate back to my actions" (IS, C, OS, F).

These students' perspectives provide insight into their citizen science experiences; how they see it being of value to their learning, what they have gained as a result, and the ways in which teachers could enhance the transformative potential of such experiential environmental education activities.

6.2.3 Citizen Science Organiser Perspectives

The four citizen science organisers spoke positively about the opportunities citizen science projects provide, as part of students' formal and informal environmental education. The potential solutions that such projects address are explained in the theme 'marriage of convenience'. The ease and flexibility of incorporating citizen science projects for student and teacher learning is illustrated within the theme 'pedagogical Swiss army knife'. 'Opening the 3rd eye' is a theme that portrays the perceived gains from experiencing nature-based citizen science projects. The links between these themes and their associated sub-themes are shown in Figure 36. Examples of codes and excerpts used to develop the sub-themes in the theme 'pedagogical Swiss army knife' are shown in Table 14 in Chapter 4.

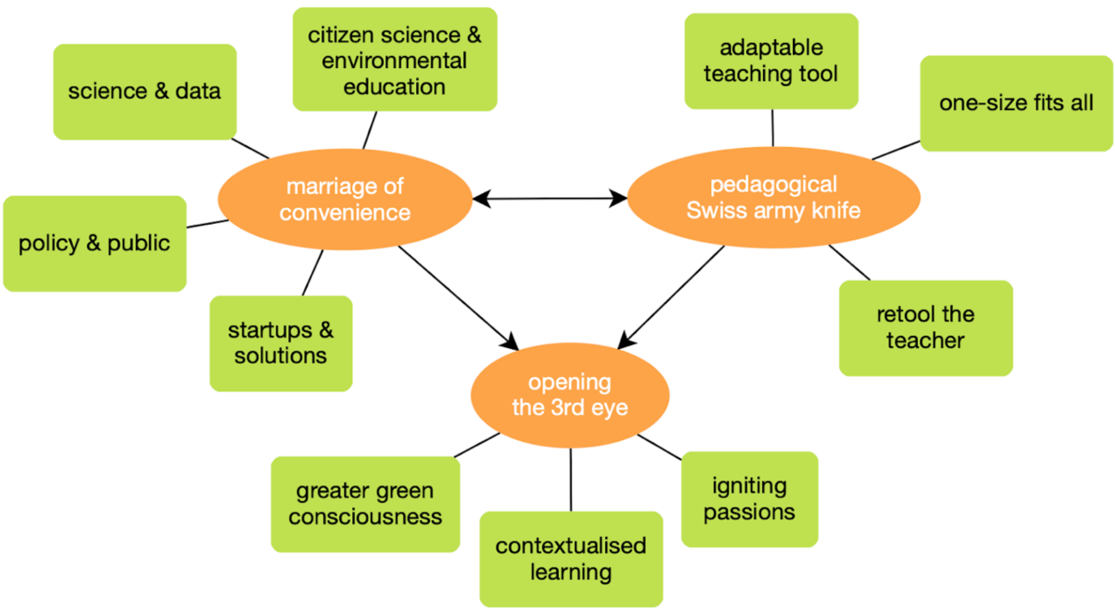


Figure 36: A thematic map of citizen science organiser perspectives about citizen science; themes are in orange ovals, sub-themes are in green rounded boxes, and the lines and arrows show association.

Marriage of Convenience

Embedding opportunities to participate in environmental investigations supported by experts is a way to enhance how environmental education is taught. Incorporating nature-based or experiential citizen science projects makes the learning more relevant and meaningful, as it is not only learning by doing, but "learning by contributing" (NGO, C). One of the citizen science organisers, who went through the local Hong Kong primary and secondary school system, felt that "citizen science is a brand new and effective education approach, because we can really educate them in reality, instead of theory. I support experiential learning. Three hours in a lecture versus one hour in the field, you cannot compare" (NGO, Co). They added how the data gathered by students in such investigations can help youth develop stronger understanding about environmental sustainability to "protect the ecology… make a balance" between nature preservation and utilization. Another citizen science organiser also claimed that these contributions have "far reaching consequences in terms of closing a data gap on urban ecology" (NGO, C).

Having the students be part of something beyond their curricular objectives was an attractive factor for some schools participating in the HKISCNC because it aligned with a particular engagement policy objective by the Hong Kong government. Within their Biodiversity Strategy and Action Plan was the promotion of "more community involvement in biodiversity and awareness, so that in itself is a big rubber stamp by the authorities to say 'yes, this type of activity [citizen science] and this type of mentality [pro-environmental] is encouraged' is a huge step" (NGO, C).

A citizen science approach afforded a practical advantage for the citizen science organiser leading the environmental start-up(S-U, Co), where they acknowledged how:

> *As a teeny tiny company, we just didn't have the resources to send people out and collect photographs for us, so we had to think outside of the box and that is kind of where the citizen science angle came in… There are people doing beach clean-ups in Hong Kong all the time, collecting trash all the time, so all they had to do was add photographs to this entire thing and that would kind of solve our problem, right? And so that is where we started for the first time, looking at citizen science as a very serious way to build what we are trying to build*

The organiser saw involving students (and the Hong Kong environmental community) in a citizen science project as a way to solve a data quantity and quality problem for the start-up, and in turn, the project provided a learning tool for teachers to locally-contextualise a topic of student interest, marine pollution.

Pedagogical Swiss Army Knife

> *Every teaching is different, just like every school is different, every student is different… Offering teachers a different way of illustrating, if you like, how citizen science and citizen science tools like 'iNaturalist' or 'Seek' can actually augment or enhance the learning experiences that students have… also enhance things like critical thinking, civic responsibility, moral studies, all that type of stuff. The cross curricular potential of citizen science can be explored.*

This citizen science organiser (NGO, C) spoke of the adaptability of the citizen science approach in an educational setting, and the gains that can result. With the range of available citizen science projects, both online and physical, they appreciated how flexibly citizen science can be brought into subjects like science, humanities and civic education. The HKISCNC citizen science organiser felt that the attraction of the biodiversity project allowed participation at different comfort levels, noting that some schools "put their toe in the water and saw how it could work… and continue it". Other schools, they noted, proceeded to use 'iNaturalist' during their own field trips to explore rural biodiversity, "so from that, it [the HKISCNC initiative] was a success" (NGO, C).

Another advantage of a citizen science project like the HKISCNC, as expressed by an organiser, was that schools could decide how involved they wanted to be and what kinds of outcomes aligned with their needs. Schools could participate during that week-long campaign or extend the biodiversity monitoring by conducting surveys through the year. A citizen science organiser suggested that for the "more progressive schools that are very proactive about these kinds of issues", there is an opportunity to advance their environmental policies to include biodiversity and stewardship, signalling "a unique selling point" for prospective school parents and students (NGO, C).

Teachers can also benefit from the exposure to citizen science initiatives as these opportunities could support their own professional development to add more skills in their pedagogical toolkit. One citizen science organiser wondered if younger teachers were keener to incorporate novel technology-based learning engagements (like citizen science projects using the smartphone app 'iNaturalist'), than older teachers, as they noted that some teachers "not doing it (participating in citizen science projects) from the bottom of their heart (NGO, C)". They hoped that the very experience of being involved would help to "change their attitude" for future engagements with citizen science. Another organiser said they purposely advertised the citizen science approach as one with great flexibility, where teachers decide the depth of the citizen science experience they felt comfortable enough to engage in. With this 'light touch' invitation, they hoped teachers would be intrigued by their experiences incorporating citizen science in their lessons and consider doing more such projects in the future.

Opening the 3rd Eye

This theme reveals what citizen science organisers perceived as the additional benefits of citizen science to oneself and the wider community. A citizen science organiser noted the students were "very excited… everyone was quite amazed" with the biodiversity on their campus (NGO, C). They described a memorable scene with a local school student participating in the HKISCNC, where:

> *He could take very good photos that I can see the eye of the ant! I don't know how long he waits. I see him kneel down… his knees on the floor and then, like, taking photos or trying different, yeah, he waited for a very long time. Very serious kid. And he took quite a few good photos he shared with us on that day.*

Their colleague in the same HKISCNC initiative suggested how being involved in such projects may "pique [student] interest" and could be subtly "tricking them into caring [about the environmental topic]" (NGO, C). They explained that students participating in the HKISCNC "get that wow factor" from recognizing that "to contribute to biodiversity monitoring, all I have to do is to take pictures on my phone? Alright, I can do that!" (NGO, C). However, an organiser of a co-created citizen science project (S-U, Co) offered a somewhat conflicted assessment of student involvement:

> *I think, for most people broadly it's like "Hey, I feel great, I've been able to contribute to something meaningful, by just by being a citizen. Something as simple as just taking a picture on my phone and contributing in a big way. So I think they feel nice to be a part of that. But I don't know if that actually translates into something long term. But yeah, definitely, with a .. like 10% or a few %, at least some percentage are going deeper into the issue and asking questions, I think that is important.*

Though they cheered the positive feelings that students may attribute to contributing to citizen science projects, this citizen science organiser shared some uncertainty about the endurance of environmental interest. Embedding the citizen science experience within a context that resonates with the students may go some way to address this issue. However, citizen science organisers are often not involved in that side of the educational experience, as one reflected, "I don't know if the teacher is doing [a lesson around the citizen science project] … if there will be a follow up afterwards, maybe that would be better" (NGO, C).

Despite the above questions, citizen science organisers were hopeful about the impact that citizen science can have on people and the planet.

> *Marrying citizen science with the society, so of course it doesn't have to be the environment or biodiversity, it could be about other stuff, but how that actually trickles down to a positive effect on society. That is something I think needs to be pushed. There are some great citizen science projects out there. (NGO, C)*

6.3 Chapter Summary

In this chapter I reported the various perspectives that teachers, students and citizen science organisers shared about environmental education and citizen science. Ideas about environmental education that were common across the three participant groups included the goals of environmental education to incorporate learning content knowledge and increasing awareness of important environmental issues. They also reflected similar feelings about how nature-based experiential education is not only an interesting way to learn, but how it can develop values and appreciation for nature. They shared thoughts about how citizen science is a new and engaging way to teach experiential environmental issues in school classes with an added purpose because the data collected is being used for real world research.

A particular finding that differed was the importance students gave to participating in citizenship action as part of their learning experiences of environmental education. Of note, this was not specifically referred to as a goal of environmental education by any teachers or citizen science organisers. Instead, teachers hope that students take action at some point down the line, after learning about the environmental issues. The greater significance teachers place on educational objectives is a topic that I discuss in the following chapter about perceptions of citizenship actions and pro-environmental behaviours.

In a similar vein, the suggestions given by students to improve the impact of their citizen science experiences asks for more time and opportunity to link their learning with their behaviours and the specific issue being studied. They asked for citizen science initiatives to be embedded within their academic learning objectives to enhance its meaning, which was a recommendation by citizen science organisers, but was not mentioned by any teacher. These overall findings are further synthesised in Chapter 8, where I discuss the significance of all these findings across the results chapters amidst the wider literature.

The following chapter shares the results of analyses of survey and interview responses about teacher, student and citizen science organiser perspectives about citizenship action and pro-environmental behaviours.

CHAPTER 7

7 Results: Perspectives about Citizenship Action and Pro-Environmental Behaviour

This chapter focuses on the third sub-research question: what are teacher, student and citizen science organiser perspectives about citizenship action and pro-environmental behaviours? The main aspects that I report on are about (i) the common actions that people are willing to do; (ii) the influential factors that motivate taking action; (iii) the barriers that discourage taking action; (iv) how more effective and less effective actions are perceived and why; and (v) what practical initiatives can be undertaken to encourage participation in citizenship action. Each of their accounts is framed around themes with evidence provided in the form of participant quotes. I share the teacher, student and citizen science organiser viewpoints in turn, and finish with analytical comparisons in the form of a table showing the extent of alignment between their three perspectives.

7.1 Teacher Perspectives

In this subsection, I start by describing what teachers think about the kinds of pro-environmental actions students partake in. Then I analyse their impressions of what effective citizenship action entails while presenting results of a ranking exercise of various student-led citizenship actions. A detailed look at the presumed barriers for students to take action is discussed alongside the challenges teachers face in supporting them. This is important in environmental citizen science used in educational settings because of the hope that such experiences can influence some pro-environmental behaviour change.

Some of the most common pro-environmental actions that teachers have observed their students take include sorting solid on-campus waste for recycling, separating food waste for on-campus composting, joining beach clean-ups, and hosting awareness and fundraising campaigns for environmental issues and NGOs. All the schools have recycling bins on campus, with varying degrees of bin density across the campus and frequency of use. Two of the eight schools (a local and an international school) have an on-campus composting machine which handles cafeteria food waste. Actions like beach clean-ups and campaigns are usually organised by student interest groups such as the schools' environmental clubs and green groups, and they often use school resources to execute them. Practical resources like gloves, garbage bags, poster paper and campus space, and logistical resources like adult supervisors, transport and community networks, are usually required for these types of actions. Some schools designated student environmental monitor roles within classes to encourage responsible energy consumption behaviours when in and outside of classrooms. These particular actions are examples of where school infrastructure and systems set the tone for norms and practices amongst the student body.

Teachers shared that it is difficult to know all the pro-environmental actions students do because there may be limited opportunities and incentives for students to reveal these to a wider audience. Some schools have a recording mechanism for students to share citizenship actions (like a portfolio of reflections for service learning and action outcomes), though these are usually private between the student and an advisor or teacher. Another issue is that where certain actions are more habitual or part of one's lifestyle, like being vegetarian/vegan or avoiding single-use products, they aren't generally discussed. One teacher wondered if taking such actions was "normalised behaviour for them now… if they're that type of student, and they… don't even realise that that's something they need to comment on" (IS, Co, Geo). However, another teacher shared their impression of how they "don't really see other students initiating anything" because it is easier to "go to the Country Park, to go to the beach and to, to pick up rubbish… they're just lazy to, to, to think of some other more creative ideas" for action (LS, C, Sci).

These perspectives begin to shed light on the many factors at play regarding what students do, why teachers think students do them and whether teachers find those types of actions to be effective. I synthesised these teacher perceptions using four themes: (i) Emotions at the helm, (ii) Learning comes first, (iii) Low-hanging fruit, and (iv) Effectiveness means effort. These themes are illustrated in a thematic map with associated sub-themes and ideas (see Figure 37). I will refer to these themes and ideas as I contextualise the findings about more and less effective actions in the later subsections 7.3.1.1 and 7.3.1.2.

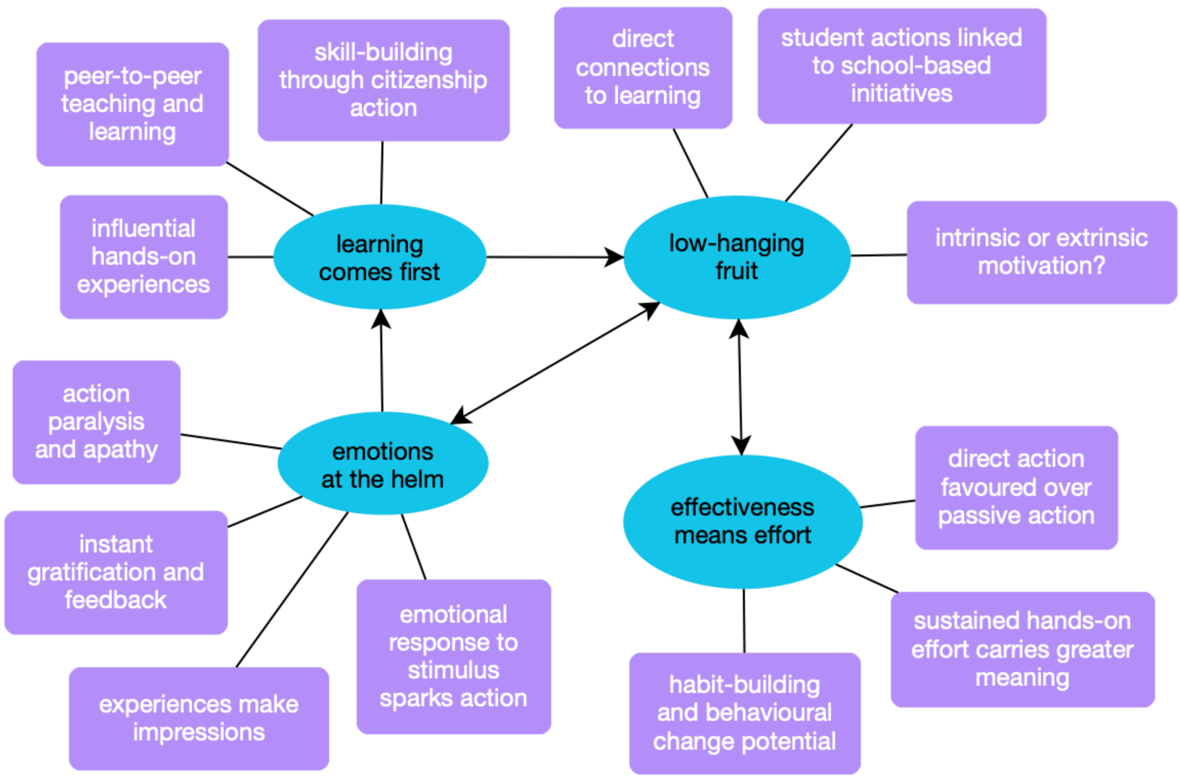


Figure 37: Thematic map of teacher perspectives about citizenship actions, Themes are in blue ovals, with sub-themes in purple boxes.

7.1.1 More Effective Citizenship Actions

During the interviews, teachers were asked to discuss and reach consensus when ranking the effectiveness of nine citizenship actions that have been taken by secondary school students in Hong Kong. During the interview I prompted the teachers with using the interactive Google Slides workspace, and for this question they saw the list of nine actions and could place the rank number next to the action (see Fig. 8, bottom right). The results of local and international school teacher impressions for more effective actions is represented in Figure 38. This chart displays the nine citizenship actions categorised into 'personally responsible', 'participatory' and 'justice-oriented' actions based on Westheimer and Kahne's (2004) distinctions about types of citizenship actions. Teachers were not aware nor were they ever told about how I categorised the nine actions into these types.

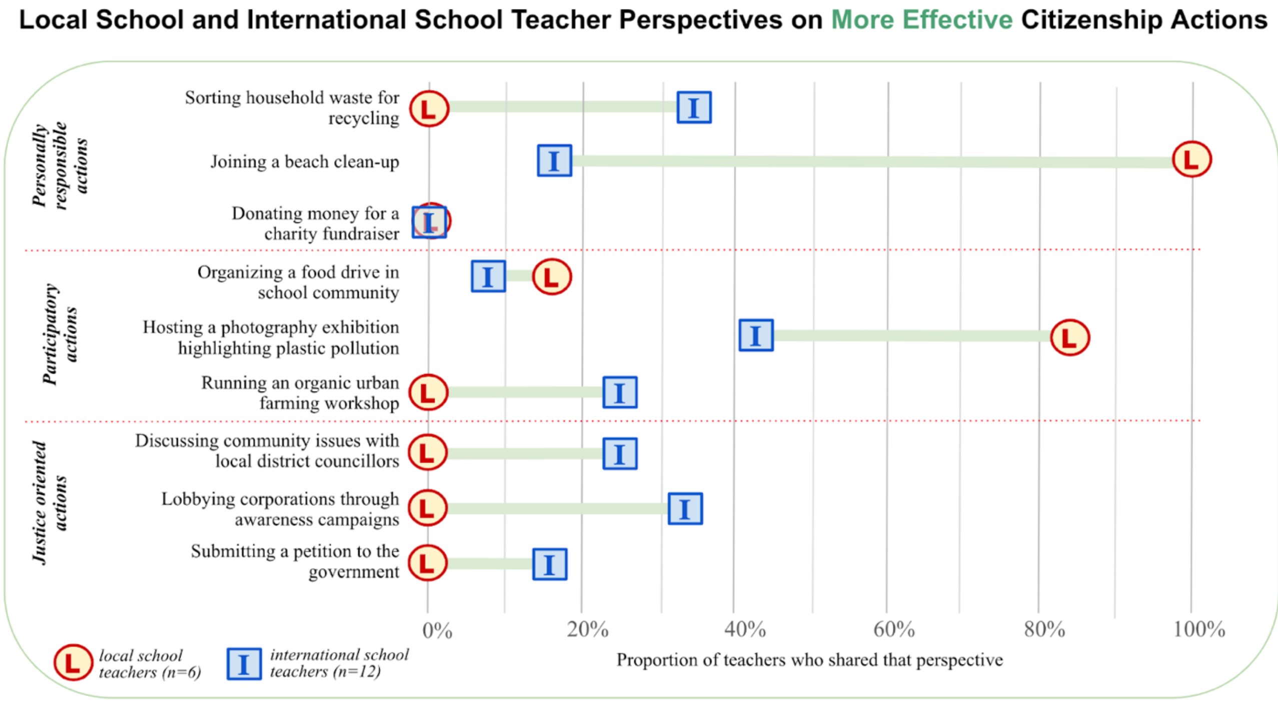


Figure 38: A chart showing how local (n = 6) and international school (n = 12) teachers' perspectives compare and contrast about which citizenship actions are more effective.

There were notable differences between the types of citizenship actions considered more effective between local and international school teachers. There were differing impressions about effectiveness for all three categories of 'personally responsible', 'participatory' and 'justice oriented' actions. Though the combined (local and international school teachers together) results show 'hosting a photography exhibition highlighting plastic pollution' (55.6%) and 'joining a beach clean-up' (44.4%) to be the top two more effective actions out of the list of nine, these are being especially favoured by the local school teachers as seen on Fig. 38. 'Joining a beach clean-up' found 100% agreement from local school teachers as they saw it as a tangible way for students to take action because it allows them to see the severity of the problem. One of the teachers thought that students might be put off with how beach clean-ups take "more time or some more effort and that can be discouraging", but they still felt it to be "an important activity" (LS, C, Sci). Other local school teachers noted that it is a "physical" (LS, C, Sci) activity where students can "see the problem and they can help to solve the problem because they, they need to pick up the, the waste" (LS, Co, Sci). An international teacher (IS, Co, Geo) suggested that it is a helpful action that can prompt reflection:

> *Even by doing the physical activity of beach clean-up, you're starting to think, well, what pollution am I picking up? Where is this coming from on a day to day basis? How much of those products am I seeing? … Then without realising subconsciously, a student might push back on how much plastic they use... I remember one of the things that's massively made me push back on my plastic use is actually seeing it on the beach.*

However, others noted how cleaning beaches does not actually solve the root causes of marine pollution: single-use plastics production and consumerism, and broken waste management systems, to name a few. A teacher felt how "in the larger global scheme of things, that [cleaning beaches] probably doesn't do anything" (IS, C, Sci). Though students might measure success with the volume of trash they take off the beach, new trash returns to the same coastlines, thus the need for beach clean-ups to happen on a regular basis. Teachers suggested how the recurring need for action due to the issue not being completely solved may generate negative emotions for students. "It's hard for them not to have immediate outcomes [of solving the problem], and that can create a sense of helplessness and apathy", a teacher proposed (IS, C, Lang). This sentiment is captured by the theme 'emotions at the helm' (see Fig. 37) where the lack of instant gratification and feedback in solving the issue can be a demotivator and lead to action paralysis.

For the other most effective action, 'hosting a photography exhibition about plastic pollution', the teachers saw it as an exercise where one would gain a lot of knowledge from curating, and for those who attend, they would leave with strong impressions that may prompt action, because a "photo can speak more than words" (LS, C, Sci). They described the impact of viewing:

> *Something very stunning, which can somehow associate, that photo where we are trying to use that similar product, for example, the sea turtle, the nose with the straw. Every time when I use a straw or when I see a straw, somehow I will associate with the blood or the pain, or something like that. And also, because of this, can somehow indirectly pushing the cooperation to act, to act. Like, I'm not sure, trying to, instead of using a straw, they are trying to use a new design of cover, the lid. Maybe a photo, although maybe it is narrow-minded, but in terms of impact, specially right now we are just looking on our phone, and maybe a very stunning photo is important.*

With 83.3% of local school teachers and 41.7% of international school teachers ranking the photography exhibition as one of the top two actions, it seems to reveal some criteria for effectiveness from the teacher perspective. Teachers discussed how effective actions are those that (i) connect environmental issues to "their own [student's] personal life" (IS, C, Sci), (ii) "educate and so then people understand and… hopefully do [take action]" based on what they've learned (IS, C, Sci), and (iii) have "shock factor" (IS, C, Sci) such that one is more "emotionally connected" (IS, Co, Geo) to the issue and (iv) are hands-on or have "physical movement [because] the activity is kind of connected to the brain, so they can remind them of what is happening in the world" (LS, C, Sci). These criteria relate to the reasons why beach clean-ups were also generally seen as a more effective action.

The above criteria are embedded within the themes 'emotions at the helm' and 'learning comes first' as depicted in Figure 37. Teachers perceived hands-on experiences to generate strong impressions, such that emotional responses from experiential stimuli would hopefully lead to students taking action. A teacher suggested how "it's best to frame issues in a way that appeals to the social justice warrior in the adolescent. So, like, the messaging can be about exploitation, and give them that kind of an incentive" (IS, C, Lang). They also delved deeper into the role emotions play in prompting student self-reflection and behavioural change, sharing they found it:

> *Frustrating that after two years, it takes showing 'Seaspiracy', which is, you know, it's quite emotive and cherry picks etc. Some of the science isn't that great, it's, it's commendable, but it's also controversial. But it takes 'Seaspiracy' to get people to say 'Okay, I'm not going to eat fish anymore'. Or you know, "Cowspiracy" to say 'I'm not going to eat meat anymore', and I do find it frustrating because the, I would, I guess, I prefer a more logical approach, but emotion seems to work.*

Teachers also valued the importance of increasing knowledge and skills when taking action, suggesting that was the more significant goal, than solving the problem. For those very same reasons, another action seen by teachers to be somewhat more effective was the "organising food drive in school community" action. They talked about how creating the activity would require a deeper understanding of the complex issue, and teachers were less concerned about solving the actual food waste and poverty situation (the learning was seen as the priority).

The remaining six citizenship actions were not chosen by any of the local school teachers as a more effective action, whereas there were varying proportions of international school teachers who felt these actions were more effective. The sole action that received no support from local or international school teachers as being more effective was 'donating money for a charity fundraiser'. The rationale for this feeling will be shared in my analysis of less effective citizenship actions in the next subsection.

One third of international school teachers agreed that 'sorting household waste for recycling' was a more effective action because it can initiate learning how the waste problem connects to one's own lifestyle and tangibly "change habits at home" (IS, Co, Geo) to address it. Another teacher (IS, C, Sci) shared experiences engaging in such discussions in a class activity:

> *Kids relate to their work in a very different way than they do to a bunch of adults explaining to them and showing them problems. And kids have different perspectives so see things uniquely different than we do. So I think that any way you can do it from a perspective that, that makes kids identify with it as their own is valuable. That's also where in that 'sorting household waste'.. do it at home. 'Where am I going to make that change? I'm going to make that change in my house.' It's very different to where you are doing that carbon footprint type of activity with kids, where you're in a classroom talking about 'stop taking flights', you know. Like, no kid is going to stop taking flights. Their parents put them on a plane, and that's where they go and that's what they do. But if you got a kid to walk around their house and start cataloguing, like, this is an area where we are generating waste, ok, how much of this waste could be recycled and it's coming from their own home, you get a different sort of ownership on it.*

These perspectives relate to the theme 'effectiveness means effort'. This theme centres around teacher perceptions that repeated hands-on and direct actions carry more meaning, and build habits and behavioural change in students. A regular, physical activity like sorting household waste may prompt students to reflect on their own consumptive habits. And as the teacher explained, if this type of enquiry is part of an environmental education lesson about one's footprint, then the learning would be anchored to their personal lives.

For similar reasons, a quarter of international school teachers found 'running an organic farming workshop' to also be effective from an education point of view, as one teacher offered how "it just starts a conversation about food and food miles and food radius" (IS, Co, Geo).

The justice-oriented actions ranged from 16.7% for 'submitting a petition to the government', 25% for 'discussing community issues with local district councillors' to 33.3% for 'lobbying corporations through awareness campaigns', in terms of the proportion of international school teachers who felt these to be more effective actions. Again, teachers considered the learning opportunities from these actions to be the priority, rather than whether actual change would occur. A teacher (IS, C, Lang) valued the experience of engaging with more powerful socio-political entities because:

> *The reality is, if you don't get legal policies and structures in place, then you're really not going to get very far. Yeah. So learning how government works, learning how to, how to get politicians on board to draft legislation. That's the kind of thing that you'd like to be able to do.*

Another teacher was optimistic that by "educating the corporations, hopefully… the corporations have more leverage than individuals" to influence change (IS, C, Sci). A local school teacher reported how "actually government have several policy schemes but because the promotion [by the government] is not good, so a student do not know the scheme", giving the impression that engaging with the government may be a complicated process especially if students are not aware of what the government has already tried to put in place (LS, Co, Sci).

A lot of the teacher impressions come from personal experiences they have had in supporting student agency, and effectiveness seems to often be linked to potential learning outcomes, as a teacher felt that "what they're doing isn't as important as what they're learning, and how that impacts behaviour" (IS, C, Lang).

7.1.2 Less Effective Citizenship Actions

While there were some actions teachers felt did not come under the less effective category (as drawn by overlapping red 'L' and blue 'I' symbols along the 0% mark of the x-axis on Figure 39), this section will analyse which less effective actions teachers did have differing opinions about.

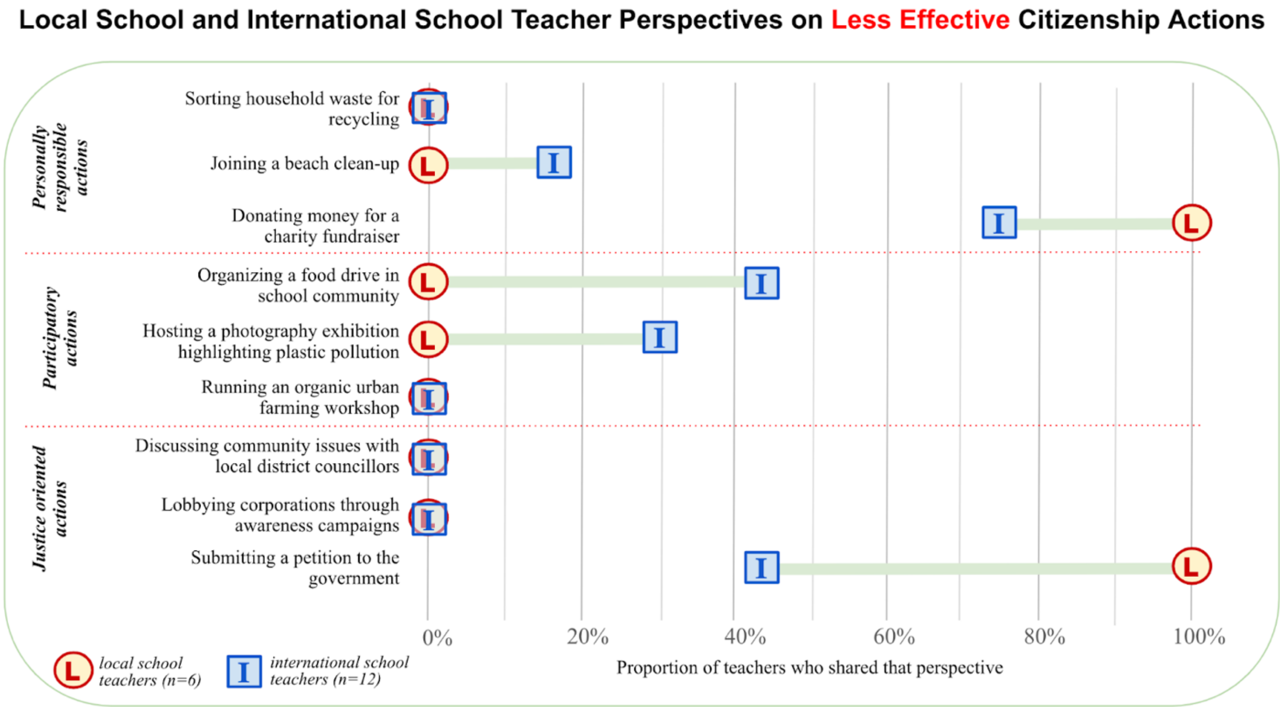


Figure 39: A chart showing how local (n = 6) and international school (n = 12) teachers' perspectives compare and contrast about which citizenship actions are less effective.

'Donating money for a charity fundraiser' saw 83.3% of all teachers ranking that action in their bottom two for effectiveness. Teachers complained how often they see fundraisers where the focus is often not on the issue or cause, but rather on the materials, most often pizzas or baked goods, being sold to raise the money in the first place. Local school teachers, all of whom felt the "donating one is the least effective" (LS, C, Sci), felt the wrong message was being delivered about how to try solving the problem:

Our students are so used to using money to solve the problem and I don't want them to continue having this idea that you know, giving money then your job is done. But I want them to really be engaged and do something… by their hands, so that they are really acting to protect the environment, instead of just, you know, using money.

Another local school teacher (LS, C, Sci) shared how donating money is akin to:

Outsourcing your duty, and trying to making yourself feel more comfortable by paying money and asking others to solve the problem for you. It does not mean that the donation is not important, but someone just consider paying or just donating money, and that's why they can turn on the air conditioner.

The teacher suggested how doing one good deed (donating money) seemingly absolves the need for further good deeds, especially if the action conflicts with one's comfort. Another concern raised was how minimally engaged students were about the issue the funds were being raised for, and that in the case of bake sale fundraisers, it often meant that students came "purely for the cake, not for the panda whatsoever" (IS, C, Sci). Their colleague noticed at bake sales, "when you just do donations, to be really honest, kids don't care. And I will also say… because the thing is, when kids donate money, it's always tied to an incentive for them" (IS, C, Sci). The incentives they referred to range from gaining house points, winning a free class party or not having to wear one's uniform for a day. For school communities who can afford these activities, teachers perceived that donating money takes little effort or consciousness. It also does little to address the issue that one may not see the difference their donation has made in a tangible way; a factor that a teacher offered about the limitations of beach clean-ups. These ideas are part of the theme 'low-hanging fruit' (see Figure 37), whereby it brings into question where the motivation to participate in particular actions lie. Is the compelling force solely from a place of great concern and capacity to make a difference, or are there other material gains one receives from taking action? I return to this question and discuss its meaningfulness in Ch. 7.4 when I compare teacher, student and citizen science organiser perspectives.

All the local school teachers and 41.7% of international school teachers considered 'submitting a petition to the government' to be an action of limited effectiveness for some similar reasons as donating money. Signing one's name on a petition does not require in-depth knowledge or critical thinking about the issue (clicktivism in the online petition realm), and it may be that emotions are driving the decision-making. They also wondered if the government would listen and interact with students with genuine intention. Many teachers alluded to the socio-political climate in Hong Kong from 2019 to 2021 being a factor in their assessment of effectiveness and how they may dissuade students from engaging with the government. One teacher explained how "just from history in the last few years in Hong Kong and knowing what it takes to try to change policy, I just feel like that [petitioning the government] has the least effect" (IS, C, Sci). This and other barriers to action I will discuss in the next subsection.

Some international school teachers were not convinced that food drives and photo exhibitions would be effective actions because of the lack of evidence they inspire students to act. One expressed their doubt about photography exhibitions because "that kind of thing happens all the time… but I don't really see it making any, any dent in terms of the actual [plastic] use" (IS, C, Sci). Similar sentiments were shared by another (IS, Co, Geo) who felt that a photography exhibition highlighting plastic pollution can be:

> *Visually appealing, but no, it's also a step too late... I think for students as well to see that, that creates apathy, because that's when they start to feel overwhelmed and stressed. And I've seen anxiety physically being induced in students as we're watching a documentary on the screen, and they get like, they feel it's a bit too much. I remember I had one student who came from science to geography, we're looking at completely different thing in geography, but they had just done global warming. And the way the teacher delivered the lesson is like, [the] world is going to end next week, and it was just too doom and gloom and, and the kid was like, I don't know what I can do. I was like that. And in that situation, it's great if you're in a position where you want to highlight a particular problem. And you know, by highlighting the problem, change can come. But if you know it, it won't lead to change in you just highlighting what the problem is. And it's falling on deaf ears, it's very hard to look at an exhibition [after] that.*

The concern this teacher shared about student reactions to information about environmental issues is embedded in the theme, 'emotions at the helm' (see Figure 37), whereby an overload of negative news can be paralysing. Though teachers have described emotions as a useful tool to spark action, they also understood the role emotions play in creating burden. This suggests teachers appreciated how a threshold exists between feeling motivated or too anxious to act.

The remaining action that international school teachers considered less effective was 'organising a food drive in school community'. Comparable to reasons against 'donating money for a charity fundraiser', teachers explained how organising a food drive as a one-time action may not have a lasting impact and, for students who donate the food, the activity lacked engaging students in a consequential way that would bring about change. A teacher questioned how taking action is incentivised for the students as "it's not like an intrinsic 'I brought this food so I can make sure that people can eat tomorrow', it's more like 'I'm bringing this food because I get to wear jeans on Friday'" (IS, C, Sci). In schools with uniforms, incentives for student to donate money or goods are often linked to not wearing one's uniform for the day, as it is an exception to be earned.

How the citizenship actions were ranked and justified by the teachers sheds some light on the criteria they used to define 'effectiveness'. For less effective actions, the criteria centre around (i) the quality and depth of student engagement and (ii) whether participation is driven by intrinsic or extrinsic motivation.

7.1.3 Barriers to Citizenship Action

This section reflects two aspects of what teachers felt the barriers to action are: one from the perspective of students and one for themselves. Their impressions are summarised in a table that categorises the barriers into personal, community and systems scales (see Table 32). The personal category is about the individual, the community category is referencing the immediate network of family, friends, and community organisations (like NGOs), and lastly, the systems category refers to the wider socio-economic and socio-political infrastructure and organisations. In addition, the barriers were thematically synthesised and illustrated in a diagram showcasing four themes and their associated sub-themes and ideas (see Figure 40). The themes are: (i) under-exposed to nature, over-exposed to problems, (ii) treating symptoms rather than the disease, (iii) wanted: helping hands, and (iv) rocking the socio-cultural sampan. I open with reporting teacher perceptions about the range of barriers students likely feel and close with the barriers teachers see for themselves. The notations in Table 32 are there to clarify that the teachers spoke about what they thought were barriers for students (most of the ideas in the table) and what barriers they experienced themselves (identified by the 'T' notation). Where barriers were relevant for both students and teachers, the 'S & T 'notation is used.

Teacher perspectives about barriers for students to take citizenship action and barriers for teachers trying to support students		
Personal	**Community**	**Systems**
S & T: Lacking time due to academic demands	Not feeling supported by family, friends, school	Sheer scale and complexity of environmental issues
Pressure to perform academically well and focus on education (instead of co-curricular activities) from parents	Can be influenced into inaction or apathy by their immediate network who are not taking action	Lack of infrastructure and coordination to address root causes of problems makes taking action discouraging
Some actions are inconvenient, physically demanding and take great effort, which may be less attractive to initiate or sustain over longer periods of time	Different levels of parent support to use personal time to take action or play in nature, instead of doing school work (assignments, studying, etc.)	Engaging with socio-political entities takes significant effort as policy change takes a long time, that time might be longer than students' attention spans or stamina
Certain issues do not seem personally relevant	Unaware of support networks to engage with in Hong Kong	Prevailing socio-political climate in Hong Kong since 2019
Limited time in nature, whether personally (with friends and family) or school initiated (e.g. field trips)	Differences and perceptions about the value of youth voice and societal traditions in local Chinese culture	Government environmental agencies organising actions with greenwashing stunts invite student scepticism
Anxiety about extent and severity of environmental problems shapes the condition of action paralysis	Role model contradictions from cultural perspectives; conflicting messaging within socio-cultural norms	Limited opportunities to be heard by city government or corporations, local district councillors more likely listen
Discouraging prior experiences creates action paralysis	**T**: Overloaded responsibilities to lead long-term initiatives	Covid-19 restrictions for school closures and gatherings
If action is not addressing the root cause, what is the point of doing small actions that are superficial?	**T**: Limited support from leadership / staff so it feels like the environmental initiatives fall on same teachers' shoulders	Environmental action seemingly not a priority for Hong Kong society and youth feel less inspired to take action
Without incentives, students feel less inclined to participate in certain actions and/or passive learning activities	**T**: Limited response and support from NGOs to carry out collaborative action; hard to develop lasting relationships	Public engagement campaigns for pro-environmental action aren't catered to youth, fail to grab attention
Overexposure to an issue may create desensitisation		**T**: less likely to push actions if infrastructure is insufficient
Takes time to develop a pro-environmental behaviour habit		
Lack of knowledge about how to take local tangible action		
Desire to change others, less motivation to change oneself		
Naivety about how change happens (time and effort)		

Table 32: Barriers to action: with label "S & T" = barriers for both students and teachers; with label "T" = barriers for teachers only; without label = barrier for students only.

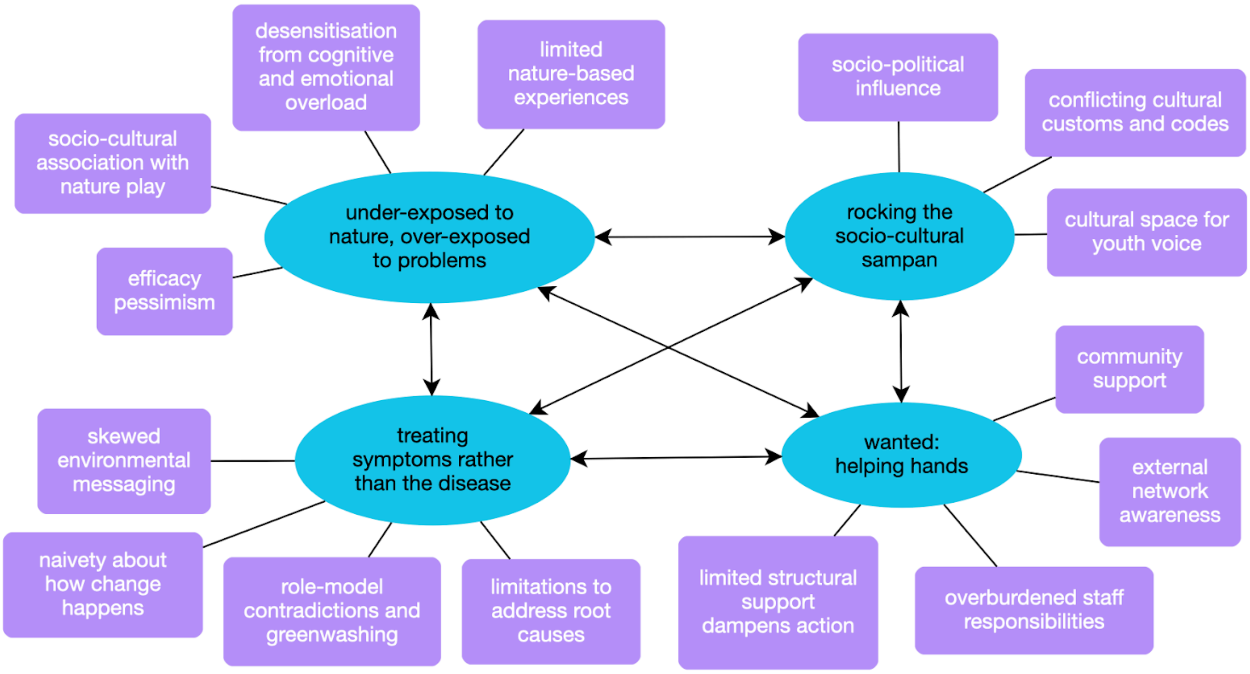


Figure 40: Thematic map of teachers perspectives about the barriers that hinder students taking action and the challenges teachers face to support citizenship action education. Themes are in blue ovals, with sub-themes in purple boxes.

Under-Exposed to Nature, Over-Exposed to Problems

This theme describes the perceived impacts on students due to limited experiences in nature and to significant exposure to distressing environmental information. It also references the perceived doubts about student self-efficacy and response-efficacy.

One of the most consistent barriers teachers proclaimed was the lack of time that students had to engage in nature and partake in pro-environmental citizenship action due to the focus on schoolwork. The value given to education drives much of the intensity students feel about their academic performance. A teacher (LS, C, Sci) shared how cultural components play a part:

> *For students in Hong Kong, it is more relied on their family background. [Though] the best way to learn is to go out and play… the parents, are just like the "Tiger Parents', yeah, so really focus on the academic side, in Asia, really focus on the academic result. So if, for example, you go out and play, your academic result will drop. This is the belief in Asian country. That's why… even for going outside, this kind of action, it is bad.*

While cultural perceptions are one aspect to consider, the multiple waves of Hong Kong Covid-19 and its impact were felt to be additional barriers. The prevailing Covid-19 restrictions and community uncertainties led to fewer opportunities to be outside and in nature, as a teacher (IS, C, Sci) recalled conversations with their students asking:

'When is the last time you've been outside? And some of them will say 'I've not been outside in a week'. And some of that is because there is no one saying 'Hey, let's go outside', and some of it is parents saying 'you can't leave our apartment, we don't think it's safe'. And so that, that inability to literally going out into the world, is troublesome.

Under-exposure to nature is one side of the coin. Teachers claimed how over-exposure to the realities of dire environmental issues is the other aspect that can hinder students taking action. As introduced in section 1.3.1.2 about less effective citizenship actions, students can be overcome with feelings of helplessness by being saturated with the environmental problems. A teacher "noticed sometimes students, they feel like it's already too late to take action… So they say 'like, whatever I do, it will not work, it will not be enough to make a difference, I will just not do it'" (IS, C, Sci). An additional aspect is how seeing the same information repeatedly can make one blind to it and may not compel one to take on new pro-environmental behaviours. Another teacher critiqued the extensive environmental advocacy campaigns across their campus, saying how "sometimes when, when you see the same poster every day, you don't see it anymore" (IS, C, Lang), and their colleague added, "you can lead a horse to water, but…" (IS, C, Sci).

A conversation between colleagues at an international school participating in a contributory citizen science project revealed their intuitions about the psychological impact of environmental issues and their temporality on taking action.

1: But environmental problems have no deadlines.

2: They even though there is a "dead" deadline...(laughing)

1: You oscillate between two, which is, I know we can do it later. I'm thinking about this, because… we were too busy. It doesn't have a deadline attached to that… [But] what [teacher 2] is saying is that there is THAT deadline, but when that happens, you just feel it's crushing. We don't have enough time to do anything about this natural threat. The timescale is either too close or too far, this has never done in your whole human time scale. And when you need to prioritise other things, sometimes we know we all know we should prioritise importance of urgency.

The challenge they've expressed is a struggle that teachers and their students deal with when deciding what actions to take, how and when. Given the temporal uncertainties about specific impacts of environmental issues, and the notion that climate change, for example, is not a "threatening issue in Hong Kong", it can make it even harder for students to undertake action (LS, C, Sci). Though "the average student would be discouraged" under the impression of the futility of one's efforts, there is hope that some students may be "spurred to action" knowing the severity of the problems (IS, C, Sci).

Treating Symptoms Rather than the Disease

This theme captures the idea that the actions and pro-environmental behaviours students take on are addressing environmental problems only at a superficial level and not the deeper root causes. Some of this is due to their own understanding of how change happens as well as what information and support they receive to carry out pro-environmental behaviours.

In an earlier discussion about the impact of actions like beach clean-ups (see Ch. 7.1.1), international school teachers brought up how some measurable actions with immediate visual impact may provide a sense of accomplishment, but would not change the fundamental drivers of the problem. With this realisation, it may dampen students' spirit to take action. A teacher saw how students "get really excited about something like a beach clean-up, or a survey on artificial reefs, and then they learn about it [the underlying causes]… how do we actually fix this problem, this glaring problem of pollution?" (IS, C, Sci). Another teacher concurred that students face "uncertainty about the impact" and students question how "one small thing… what difference does it really make?" (IS, C, Sci).

Some teachers have the view that students are not necessarily aware of what it takes to initiate deep change to fundamentally solve problems. This may come from short-sighted comprehension of one's impact, the sense that advocacy to influence others to act is sufficient to initiate change or the limited experience students have to focus on solutions to an issue over a long period of time. A teacher (IS, C, Lang) spoke of how some students gravitate towards certain types of actions that merit attention, yet only require a little effort:

> *There's that, that need for, kind of, social recognition that I think is quite strong. And to some extent, the, the desire for an almost, like, superhero cape, whereas the grunt work that has to be done to, to sort of bring about change is, is less appealing. So some of it is, I think, almost a naivety, one of the barriers is almost a naivety about how change happens, and how fast it will happen. Is a sort of a lack of experience with that, and then there's a frustration that sets in… you know, it's taking so long for something to happen… I think helping them see the long view… can be really important.*

Their colleague (IS, C, Sci) added an observation of this 'light touch' citizenship action phenomenon, where students feel like they have contributed without necessarily creating a change.

> *If you want to effect change, and think you need to go out into the real world… it is very easy in the digital age to… start one campaign… on a computer. At the end, you get people to click a button. And that's all there is. That does not actually end up with any behavioural change, because people are bombarded by hundreds of these potential polling things on the computer.*

These challenges with participating in citizenship action are further complicated by the ways in which leadership in this arena is demonstrated to students. Some schools engage with external organisations, like NGOs or environmentally-focused government agencies, to collaboratively take action. These relationships have the potential to strengthen the collective impact. However, if little progress is made over time despite admirable objectives, it can be discouraging when "you see these NGOs start and they have amazing, you know, goals, but then they don't really get anywhere… like nothing really happening. I feel like that does affect the teachers, ultimately and then that affects the students" (IS, C, Sci).

On a more complex level, when the values of organisations facilitating environmental activities do not completely align with the schools they work with, the hypocritical nature of leading green actions is brought to the fore. A teacher (IS, C, Lang) described the scenes of a beach clean-up experience organised by an environmental government agency:

> *They took us to the beach where almost everything had been cleaned up except these little cigarette butts. So we, we collected quite a few cigarette butts. They had us take a picture with a banner that was more plastic than we had picked up, that had the year on it. So it was totally not reusable. And then, look, gave us a little plastic crap as a souvenir. So the whole mindset is about, about a public performance of environmental action. That is, that is, just like, promotional and it's not in any way meaningful… I think some of the students definitely picked up[on the contradictory actions of that environmental agency]... I did hear, at the time, some students asked 'what is this?'*

This demonstrates how one may begin to question the sincerity of entities tasked with leading pro-environmental action in a highly public manner. This type of greenwashing may erode students' hope and trust that their efforts will be supported by local socio-political systems.

Rocking the Socio-Cultural Sampan

This theme is about the social and cultural norms that play a role in making it more challenging for students to take action. In the metaphor that makes up the theme name, instead of 'boat' I use the Hong Kong equivalent 'sampan' as a nod to the local culture.

Various teachers suggested how students can be influenced by their home environment and the pervasive values and attitudes towards nature. They suggested how "conversations you have at home… do lead you in how you see the world" (IS, Co, Geo) and that one's habits are "fairly deeply seated in your identity and deeply seated in your culture, deeply seated in all things and it takes time to digest and change" (IS, C, Sci). A local school teacher felt that there was a "cultural problem, we [Chinese people in Hong Kong] … do not think that in terms of environmental issue… I do think that it is not the very top priority among the normal family" (LS, C, Sci). "If your parents aren't going to be perhaps very interested… or talking from a very laissez faire kind of attitude on, on, on how we need to be environmentally sustainable, then you'd find students perhaps listening to their opinions", offered another teacher (IS, Co, Geo).

One aspect is about engagement with knowledge, but another angle is about a students' capacity to challenge what is considered the norm socially, culturally and even politically. In Chinese families, it is a common custom to respect your elders and follow what they say. As one teacher claimed, "there might be some cultural barriers in terms of, you know, how much they [students] can influence decision making… regarding people who are older than them" (IS, C, Sci). How much student voice is valued can vary from family to family, culture to culture. This can make it difficult for students to engage in citizenship actions that may run counter to what is considered normal practice. For example, important Chinese cultural festivals include high levels of consumption (buying new clothes, buying gifts, feasting with meat and fish, etc.) which is in opposition to pro-environmental behaviour.

Moving to the political arena, one teacher (LS, C, Sci) raised the issue of how socio-cultural practices, or the lack thereof, may influence one's engagement with government bodies to push a pro-environmental agenda. They suggested how students in Hong Kong:

> *Can't see the effect, the direct impact, because it is really [to do with the] time to do some policy change, so they can't really feel that for lobbying [the government on environmental issues]... if you talk in the U.S.A, the students like it, it's their culture. But in Hong Kong, the students, they can't really see the effect and immediately it's like 'I'm writing a letter to nobody', so this is my feeling. They don't know whether they will have some kind of feedback [from government]... so political things might not be too good.*

The other is how controversial or uncertain it has become for young people to engage with the government because of the significant socio-political events in Hong Kong since 2019. About 40% of the people arrested during those protests (which prompted schools to close and switch to online learning for weeks at a time) were students (Hong Kong Free Press, 2023). Protests of any kind have not been possible partly due to the fear that (i) any criticism could be seen as an afront to the Hong Kong government, (ii) could violate the still ambiguously-worded security laws that went into effect in June 2020, and (iii) teachers have come under pressure to discourage their students from participating in actions, like protests, that may upset the social norms of the territory (Hong Kong Free Press, 2023). The other reason protests have not been possible has been because of Covid-19 related crowd gathering bans that have limited public gatherings of more than 4 people between 2020 and 2022, which only were lifted on 29th December 2022 (HKSAR Press Release, 2022b). As discussed earlier there is a dispirited feeling about the value of communicating with local authorities who have ignored youth voice in the past. As a teacher revealed, "what might be possible in the U.S.A [protests], might not necessarily be in Hong Kong".

Wanted: Helping Hands

This theme focuses on what the teachers' challenges are to support their students in partaking in citizenship actions. It centres around the need for greater support from their colleagues and school leadership, and the wider socio-political community infrastructure.

One of the most common responses from teachers was about how busy they were to continue supporting pro-environmental initiatives with limited support from their colleagues and school.

> *There's how many of us… staff with three hats: we're all teachers, CAS [creativity, activity, service], a component of the international baccalaureate] activity leaders and tutors that go beyond like advisors in the morning. And so I think that that makes only a certain amount [a teacher can do] sustainable". (IS, C, Lang)*

To address the constraint about time, teachers wished for environmental programs and practice to be embedded within the school system so that it encouraged the whole community to participate, and not just the motivated few. A teacher (IS, C, Sci) desired:

> *More support within the school, you know. If they [school leadership] made in the environment, like one of their key missions [of the school] is, like, to be sustainable. That would really help because then every, all the teachers would, kind of, fall in line, right?... But then when you bring up sustainability, they [most teachers] are like, 'Wait, is this just extra work for me?', you know. Like, there's not like, an [understanding] like, 'No, we have to do this because this is a goal of the school'... It's even when we run projects, like iNaturalist or citizen science, it's kind of like, 'Oh yeah, [our small group] is doing that'. It's not like, the [whole] school is doing this.*

They felt inhibited to carry out citizenship actions due to "barriers as far as policy and government" is concerned. They expressed frustration at how they have "an oyster shell recycling program that I've been dying to start, but they [the government] won't let you go and put your oysters back in the ocean. You can throw trash in the ocean, but you can't… start an oyster reef". In addition, the lack of impact made by organisations with environmental objectives over long periods of time was another deterrent to becoming more involved and encouraging their students to collaborate. They noted "there's a lot of NGOs, I'm sure, you know, in Hong Kong that have just been doing the same thing for years and years and years, and nothing has changed" (IS, C, Sci).

Despite these significant barriers that make it challenging for teachers to undertake projects that support their students to take a variety of citizenship actions, teachers want to "act as a model" for their communities to take action however they can (LS, Co, Sci). A teacher alluded to the duty of teachers, when they proposed how "we [would] be failing them if we weren't actually creating a sense of ownership and responsibility in the students" (IS, Co, Geo).

7.2 Student Perspectives

In this subsection about student perspectives, I begin by sharing the typical pro-environmental actions that they partake in. Then, I present the results of discussions during student interviews about which factors from environmental behavioural psychology they perceive are the most and least influential for encouraging taking action. Following on from that is a detailed analysis of which actions students consider to be the most and the least effective. And finally, I synthesise a series of tangible recommendations which students suggest will encourage more of their peers to initiate pro-environmental citizenship action.

Across local and international schools, the most common ways students showed their concern for nature and environmental issues was to address the waste problem. Recycling systems usually comprised the triple paper-metal-plastic bins at designated sites on school campuses, and often with paper recycling bins in each classroom for added convenience. Energy waste was also tackled by campaigns to monitor air conditioner, lighting and electronic equipment use by student volunteers in school-specific programmes like 'Green Guardians'. Some students pointed out that recycling and mindful energy use behaviours were also encouraged at home and therefore became more of a habitual exercise. For schools that had invested in on-campus composters, they encouraged students to be conscious of their food waste footprint. Off campus, students would join beach clean-ups and tree-planting activities to engage in direct action where they could physically see the result of their efforts.

Other common initiatives saw students organising awareness and fundraising campaigns for environmental issues like biodiversity conservation, animal rights, access to freshwater, climate change and ocean plastic pollution. The campaigns usually took the form of posters, student-led talks and food sales to encourage peer engagement. The fundraising efforts were most often in support of established environmental NGOs that students and/or schools had a prior relationship with, rather than to pay for unique in-house environmental projects.

7.2.1 Influential Environmental Behaviour Psychology Factors

A particular question during the interviews required students to categorise seven different factors derived from environmental behavioural psychology that typically influence people to take action, into 'more influential' and 'less influential' groups. The results of those discussions are graphed to show comparisons based on school type (local vs. international schools, see Fig. 41) and by student age (young secondary (11 - 14 year olds) vs. older secondary (15 - 19 year olds), see Fig 42). It is important to note that these results reflect what the students perceived were influential factors for themselves. In contrast, the earlier results about influential variables on behaviour from regression analyses on the survey data revealed which psychology variables had statistically significant influences on behaviour.

The seven psychological factors that could influence environmental behaviours are:

i. knowledge about environmental issues
ii. influence of others
iii. feeling your actions make a difference about the environmental issue
iv. your own personal motivation
v. personal values and attitudes about the environment
vi. having skills to take pro-environmental action
vii. experience taking some form of pro-environmental action

The top two most influential factors as perceived by students attending local schools were 'knowledge about environmental issues' and 'your own personal motivation', with 92% of local school students in agreement (see blue bars in Fig. 41). One student explained how if "I know more about these issues, I will know the severity of the problem, and that would push me to take action" (LS, Co, OS, M). The top two most influential factors as categorised by international school students were 'feeling your action makes a difference about the environmental issue' and 'personal values and attitudes about the environment', with 79% of international school students in agreement (see red bars in Figure 41). When considering the importance of response-efficacy, the idea that one can make a difference, a student expressed that "if you find out that, like, it [taking pro-environmental action] didn't really do anything, it kind of discourages you from, like, continuing forward, and I guess, like, feeling that it makes a difference, it gives you more motivation" (IS, C, OS, F).

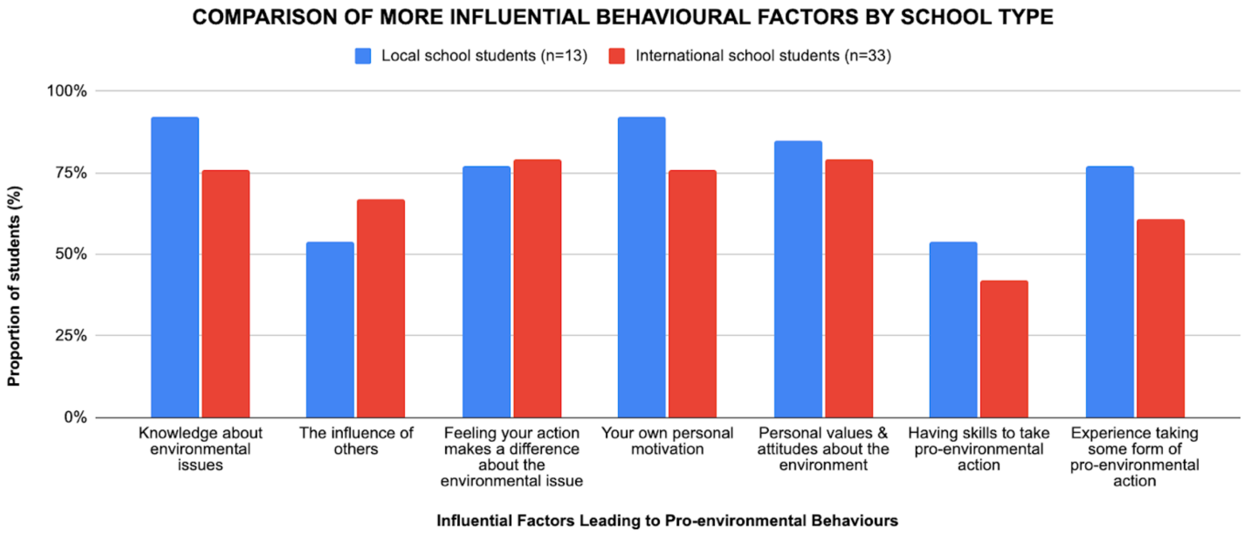


Figure 41: A bar graph comparing the local and international school student perspectives about the psychological factors that influence environmental behaviours.

Local school students (n = 13) felt that 'having skills to take pro-environmental action' and having 'experience taking some form of pro-environmental action' were more influential than how international school students (n = 33) perceived the same factors, by a difference of 12% and 16% respectively. International school students perceived 'the influence of others' to be more influential than local school students by 13%, compared to local school students. There is some consistency for both local and international school students in that the 'influence of others' and 'having skills to take pro-environmental action' aren't seen as influential compared to the other five factors. However, overall it can be seen that all the factors are supported by the majority of the local school students (over 50%) and that six of the seven factors are supported by the majority of the international school students (the exception is 'having skills to take pro-environmental action').

When comparing the responses about influential factors by student age, Figure 42 reveals that younger secondary students (11 - 14 years old) felt that 'knowledge about environmental issues' is the most influential factor, while older secondary students (15 - 19 years old) found 'personal values and attitudes about the environment' to be the most influential. "Once you know the problem… it will activate" the rest of the psychological factors to motivate one to take action, a student remarked (IS, C, YS, M). Another offered how personal values and attitudes were more important than having skills or experience, saying, "It's not like 'ah, I know how to do this'. It's more, I'm passionate about this and I want to do this!" (IS, C, OS, F). The older students distinguished how one's values and attitudes, and one's own motivation are the primary factors that initiate the feeling to take action, while the influence of others and skills are secondary; these factors encourage one to continue taking action. Though the factors of 'feeling your action makes a difference about the environmental issue' and 'your own personal motivation' are considered to be quite influential for both the younger and older groups of students, they are consistently more influential for the younger students by 16% and 12%, respectively.

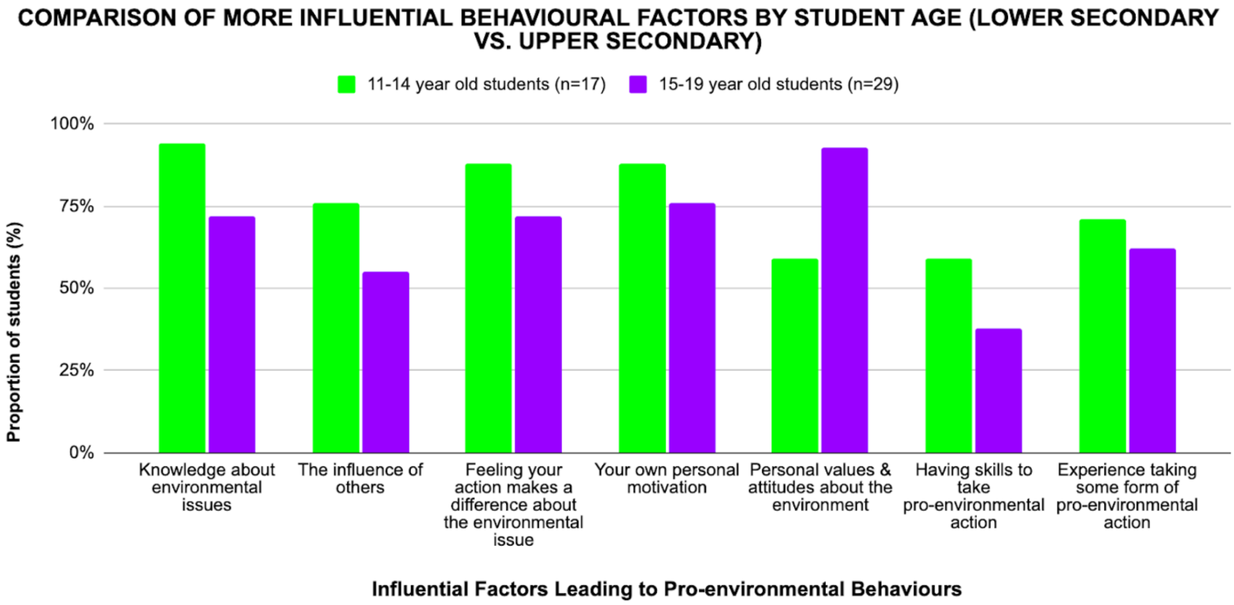


Figure 42: A bar graph comparing younger secondary and older secondary school aged students with regards to the psychological factors that influence environmental behaviours.

Seventy-six percent of the younger secondary students felt that 'the influence of others' was influential, compared with 55% of the older secondary students, with multiple local secondary students highlighting that when "you see your parents also do that [recycling]... you… also copy that kind of behaviour" and it is like following "the protocol" (LS, Co, OS, M). The least influential factor for both age-groups is 'having skills to take pro-environmental action', an element that wasn't seen as necessarily holding one back from doing an activity because "what only matters is if you're helping, nobody cares how much skill you have… as long as you're working cooperatively" (IS, C, YS, F) and that "you just need to have commitment" (IS, Co, OS, M).

When considering the same influential factors broken down by school type and by age (see Figure 43 and Figure 44), the data shows greater similarity in how older secondary students think regardless of school type, but greater differences between younger secondary local and international school students. Of note is the disproportion of participants by age and school type, as shown in each of these bar charts' legends.

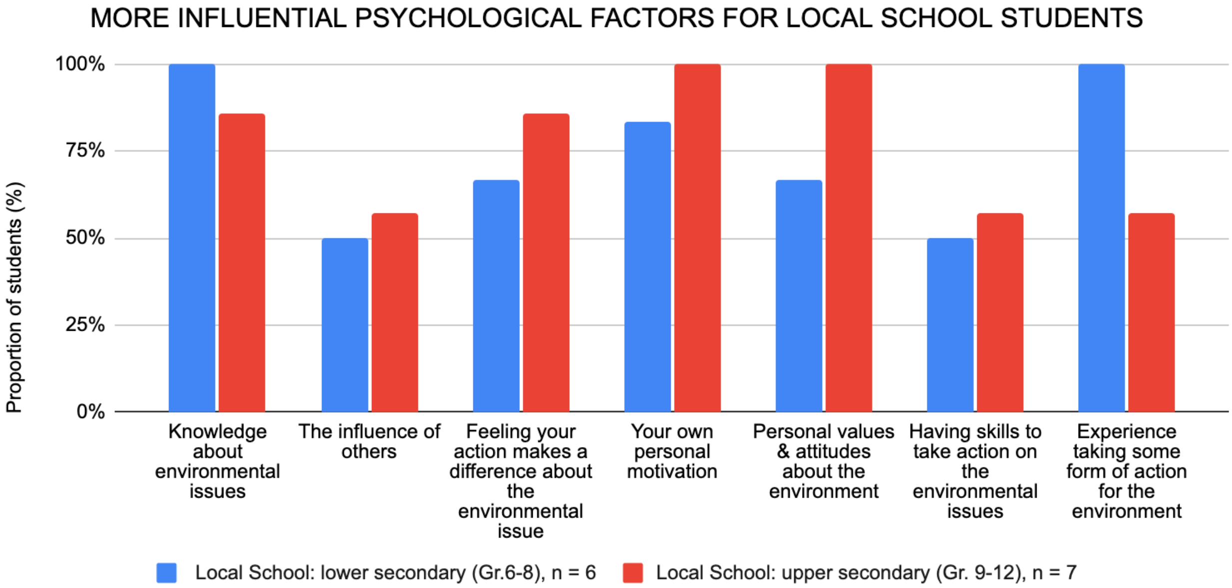


Figure 43: A bar graph comparing younger and older local secondary school aged students with regards to the psychological factors that influence taking environmental action.

While younger secondary students in local and international schools felt that 'knowledge about environmental issues' was one of the most influential factors towards behaviour, only the younger local school students felt 'experience taking some form of action for the environment' was just as influential. On the contrary, it was tied as the least influential factor for younger international school students. Almost all of them agreed that 'feeling your action makes a difference about the environmental issue' and 'the influence of others' were the most influential factors to encourage them to act, while their young local school counterparts felt these elements were some of the least influential to behave pro-environmentally.

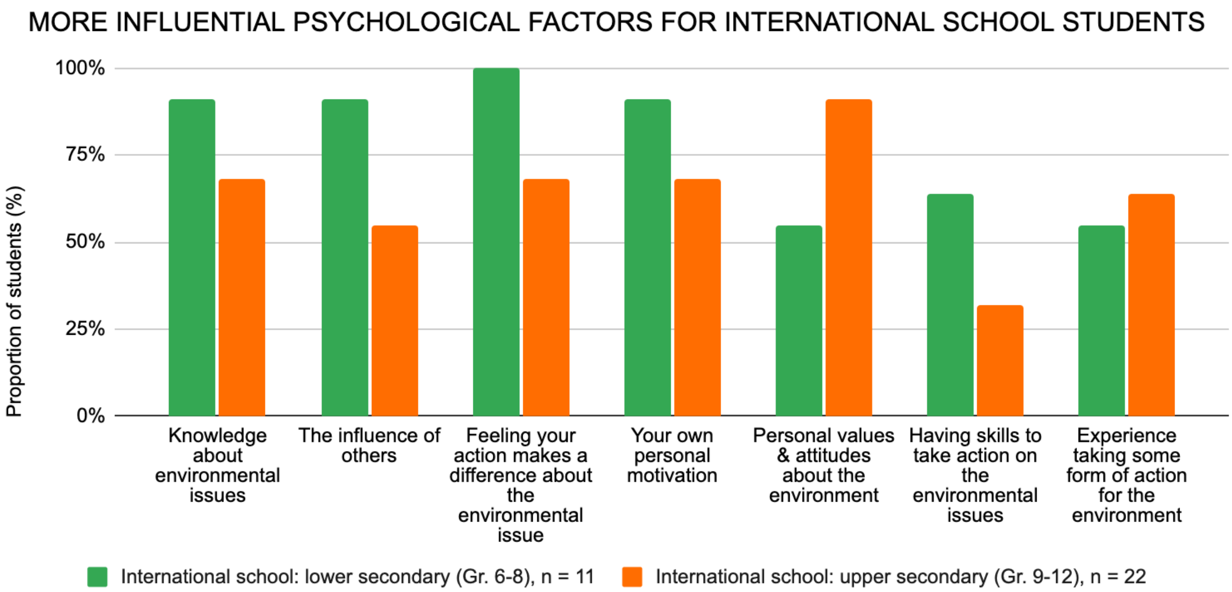


Figure 44: A bar graph comparing younger and older international secondary school aged students with regards to the psychological factors that influence taking environmental action.

These sharp contrasts are reduced when comparing the older secondary students at local and international schools. Both groups of students agreed that 'personal values and attitudes about the environment' and 'your own personal motivations' were two factors that most influenced them towards taking action. 'Having skills to take action on the environmental issues' is the least influential factor for both groups of students, as shared in an earlier quote that alluded to one's motivation coming from passion rather than from having the necessary expertise to act.

7.2.2 More Effective Citizenship Action

During the interviews, students were asked to discuss and reach consensus when ranking the effectiveness of nine citizenship actions that are typical of initiatives taken by secondary school students in Hong Kong. The results of their impressions for more effective actions analysed by school type is represented in Figure 45. This chart displays the nine citizenship actions categorised into 'personally responsible', 'participatory' and 'justice-oriented' actions based on Westheimer and Kahne's (2004) distinctions about types of citizens.

From the perspective of the three citizenship action categories, 'personally responsible' actions seem to be more consistently viewed as more effective in addressing the environmental issue. Similar proportions of local and international school students ranked 'sorting household waste for recycling' (about 20%) and 'donating money for a charity fundraiser' (about 25%) as more effective actions that one could take. Sorting household waste was a hands-on activity that could be done quite easily by oneself. Some students saw charities as having the expertise to address their environmental issue of interest, and felt it more effective to financially support them rather than attempting to reinvent the wheel and implement a solution themselves, as students would likely have much less experience. Others were more sceptical; some charities "are not transparent with where the money goes" (international school student).

'Joining a beach clean-up' was perceived to be the list's most effective action, though with differing levels of support and rationale. A majority, 69.2%, of local school students felt that way, compared with 27.3% of international school students. In particular, the older international school students (15-19 years old) underlined that beach clean-ups needed to be done regularly to be effective, but that doing a "beach clean-up is like… reactive… you're fixing the issue that is caused by the issue, but you're not thinking [about] the actual issue itself… the root cause" (IS, C, OS, M). Those students expressed hesitancy about the effectiveness of beach clean-ups because these acts were like band aids; unless the waste is dealt with at the source, it will always return to the Hong Kong coastline. Beach clean-ups are one of the most common actions that Hong Kong students participate in, and local school and younger international school students viewed it as the most immediate, visible and quantifiable way to make a difference about an environmental issue.

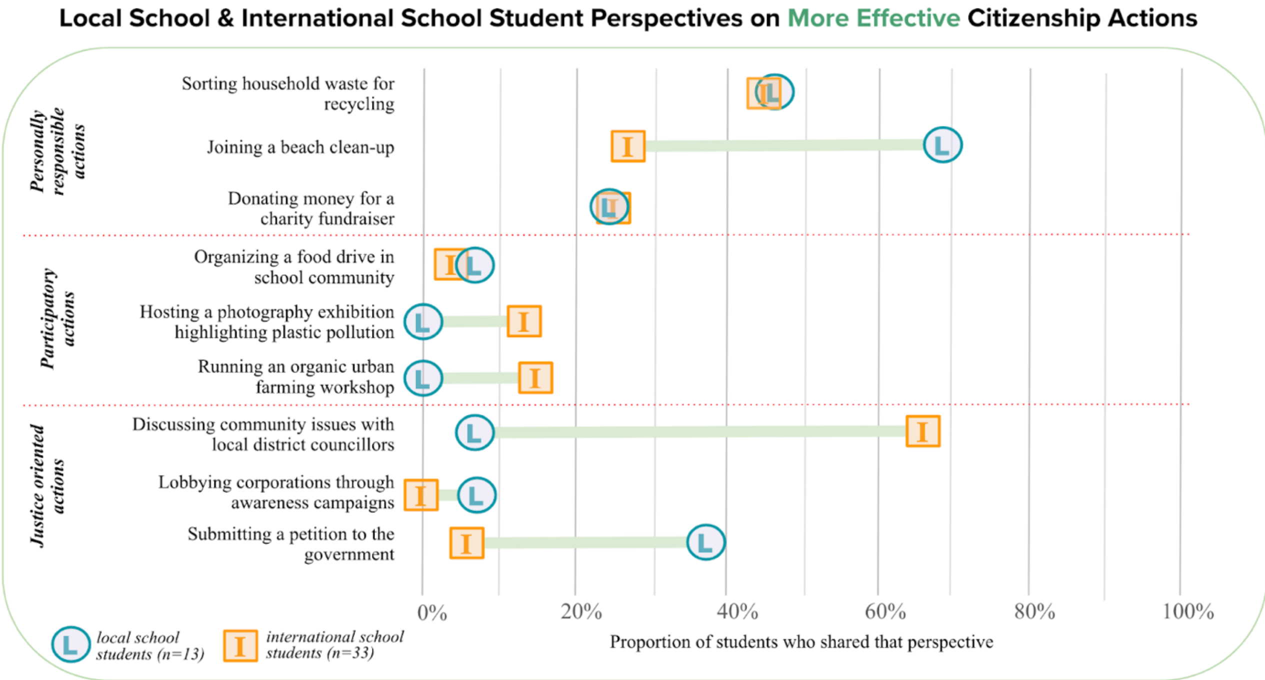


Figure 45: A chart showing the nine citizenship actions grouped into citizenship action type categories and the proportion of students who felt those actions were more effective, split into school type: local school (n = 13) and international school (n = 33).

A minority of international students considered the group of 'participatory' actions as effective, while no local school students felt that either 'hosting a photography exhibition highlighting plastic pollution' or 'running an urban organic farming workshop' should be considered as more effective actions to take. Though these activities were seen as useful, they were not perceived to leave that significant an impact to address their respective environmental issues.

The 'justice-oriented' actions were perceived in diverse ways. Notable differences between local and international school students were seen for 'discussing community issues with local district councillors' and 'submitting a petition to the government'. International school students felt discussing with local councillors to be one of the most effective actions to take (66.7%, compared with 7.7% of local school students) because they felt more likely to be heard by people with authority who have the "power to make, you know, large scale or medium scale changes" and address root causes with weighty resources (IS, Co, OS, M). On the other hand, local school students felt more strongly about engaging with big government with 38.5% of them, compared with 6.1% of international school students, saying that because they have the "largest amount of resources" and if they "take the actions… it'd be more efficient" (LS, Co, OS, M). The local school students emphasised the wide and influential impact of successful petitioning to the government, while international school students expressed uncertainty about the lengthy process and the likelihood of being given attention in the first place, a topic I discuss further in the next subsection. It should be noted that all the local school students who represent the

38.5% in favour of petitioning the government came from a school whose teacher specifically taught about the ways in which the Hong Kong government has developed pro-environmental initiatives.

When considering the students' views about effective actions, the ideas can be synthesised into two main themes: 'me, myself and I' and 'the tables are starting to turn', as shown on the thematic map (see Fig. 46). Examples of codes and excerpts used to develop the sub-themes in the theme, 'Me, myself and I' are shown in Table 13 in Chapter 4.

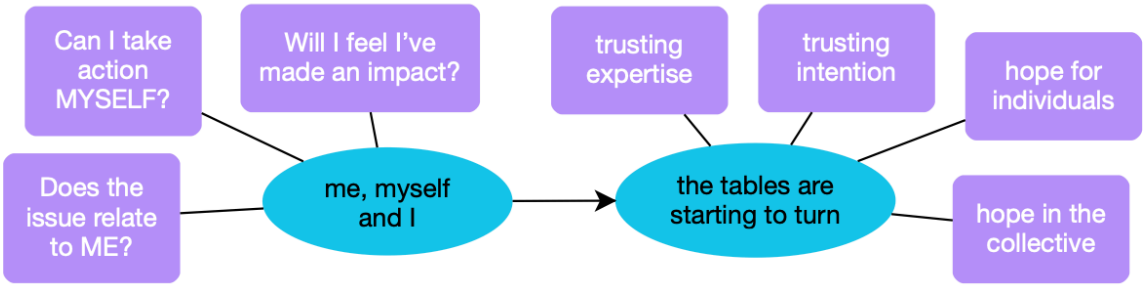


Figure 46: thematic map of student perspectives about more effective citizenship action. Themes are in blue ovals, with sub-themes in purple boxes.

'Me, myself and I' references pivotal questions that students consider when taking action: (i) does the issue relate to me?; (ii) can I take action myself?; and (iii) will I feel I've made an impact? If the answer to any of the questions is 'no', there seems to be a lesser likelihood of them participating in that particular pro-environmental action.

As I report in Ch 6.1.2 under the theme 'a guiding light', an important aspect of contextualising environmental education is to localise and personalise it. The same idea carries forward when students consider how to apply one's environmental knowledge by taking action. One student recalled listening to a talk about "the waste that's in Hong Kong… the numbers are so really frightening and it really makes me want to recycle more and to not, like, waste so much" (LS, C, YS, M). If the issue relates to student concerns, they feel motivated to take "action [that] is [coming] from ourselves" (LS, C, YS, M). Actions that don't require too much effort or can be incorporated into one's habits, such as sorting household waste for recycling, are considered "easier to organise" (LS, C, YS, M) and more manageable even for an individual. The element of impact is a powerful one because if "I can see the change that's actually happening, then I'm more motivated" to act (IS, C, YS, F). Another student explained "as long as I take them [beach trash] out, the ocean is gonna be cleaner. I think that's the logic… even it's a small step, as long as I'm seeing changes, that's good" (IS, C, OS, F). However, the same student also shared the demotivating side of having no noticeable influence on an issue that matters to them:

> *I understand there's coral bleaching, but there's nothing I can do. Like, there's something I can do about it, but what? Because I'm not seeing change, I'm not seeing what I can do to help and I'm not seeing positive effect because of me. And that does not motivate me to continue.*

With the tendency to measure one's contribution tangibly, feeling that one has made an impact is a significant driver for taking action (see Figure 41 showing influential psychological factors).

As students discussed what effective citizenship actions involve, there was a sense of hope and trust, as captured by the theme 'the tables are starting to turn'. There was an appreciation of greater environmental consciousness and a growing movement to respond to the myriad environmental problems at the individual and grassroots level, as described in earlier sections. At the same time, students acknowledged that sometimes the motivation to take pro-environmental action may not come from one's environmental values, but may emerge instead from strategies for self-preservation. A student (LS, Co, OS, M) spotlighted this aspect from a company's perspective, suggesting that if an entity's wasteful practices were exposed to the public:

> *They're actually losing popularity… So… maybe they'll start actually doing more environmentally friendly things, that's to be gained popularity… And if there's any… competitors, I think, looking at the company, how they, they, usually are [at] the top… And then… their reputation decreased because of such a thing [public exposure of wasteful practices], I think they also teach the other rival corporations to actually come up with more eco-friendly ideas… use the process [of] competition… So they will know how to efficiently reduce the ecological costs they put on an environment… it'll be a loop like this.*

Regardless of the non-environmental motivational origin to implement green initiatives, students interpreted these gestures in a positive light. This links with the ideas of trust in the expertise and intentions of organisations and systems with the capacity to have a larger impact. One student proposed how NGOs had experience of providing solutions and that if they were "aware of how to spend the money, they can spend it more effectively because they have more money coming in", with the help of student-organised fundraisers (IS, C, OS, M). Similarly, the actions taken by entities with greater power and resources, like local district councillors, amounts to "change which lasts over a long period of time", the student continued.

In the same exercise where students ranked the nine citizenship actions in terms of effectiveness, they shared their rationale for the actions they felt to be less effective and what were the many barriers that made taking action difficult in the first place; these are the topics I discuss in the following sub-section.

7.2.3 Less Effective Citizenship Action and Barriers to Action

While there were some similarities about effectiveness, or the lack thereof, for 'personally responsible' and 'participatory' actions amongst local and international school students, Figure 47 displaying least effective actions, shows there were large differences in perspectives about 'justice oriented' actions.

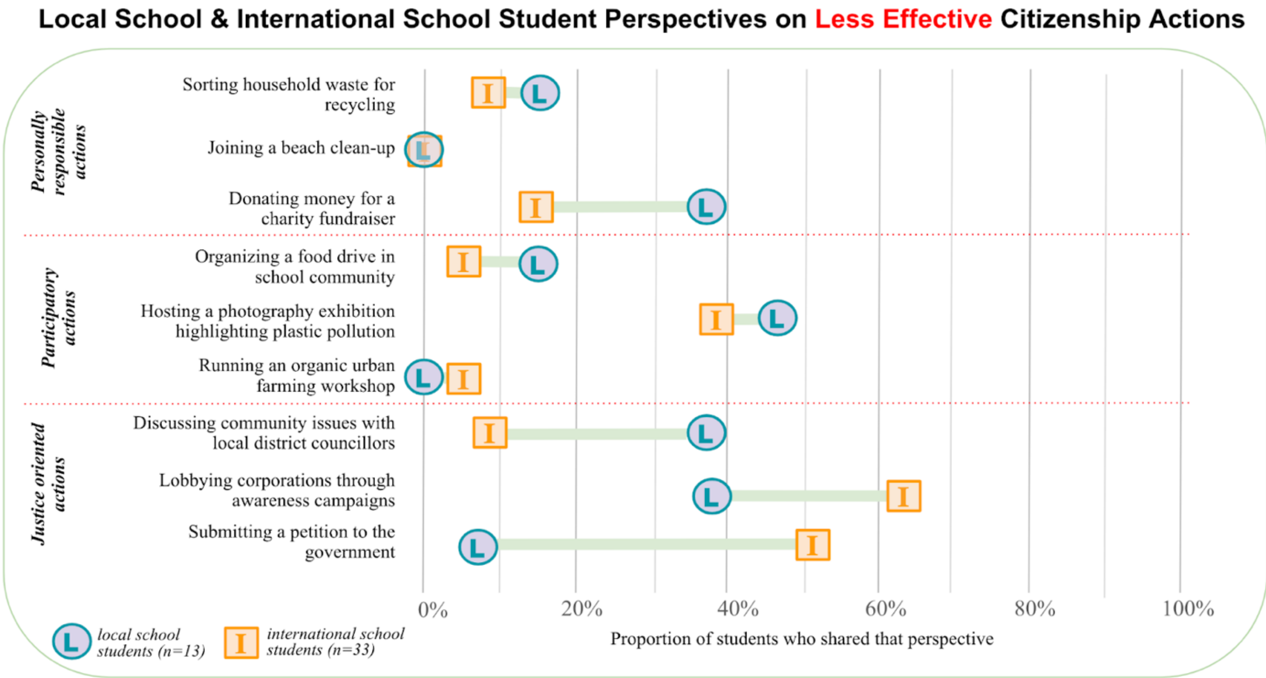


Figure 47: A chart showing the nine citizenship actions grouped into citizenship action type categories and the proportion of students who felt the actions were the less effective, split into school type: local school (n = 13) and international school (n = 33).

In the 'personally responsible' actions, 38.5% of local school students felt that 'donating money for a charity fundraiser' was one of the least effective actions, because it was a slow process to create change, and a student wondered if their "money would actually affect… the environment that much" (LS, Co, OS, M). Despite this concern, an almost equal proportion of local and international students (23.1% and 24.2%, respectively) felt it to be one of the most effective actions to take (see Figure 45).

One of the actions that students felt was quite ineffective at addressing the environmental issue was 'hosting the photography exhibition highlighting plastic pollution' because it may not necessarily inspire people to take action. Without explicit messages about how it relates to one's habits or how one can positively contribute, one response was "So what? What should I do?" (IS, C, YS, M). There is also an element of 'out-of-sight, out-of-mind', with another student, who has seen several such exhibitions, suggesting that "as soon as you walk out the doors, it's completely out of your head" (IS, Co, OS, F).

'Lobbying corporations through awareness campaigns' was considered one of the least effective citizenship actions by 38.5% of local school and 63.6% of international school students. Their rationale centred around the likelihood of being ignored as society is "so focused on capitalism… if we're asking them [the corporations] to do things that would make them lose money, they're least likely to want to do it" (IS, C, OS, M). A wider disagreement about the least effective actions came from local school student perspectives about 'discussing community issues with local district councillors' (38.5% of local school students, compared with 9.1% of their international school counterparts). There was an impression that even if one were to engage with district councillors, they did not really have much power under the city government to enact effective changes. About half the international school students (51.5%) viewed 'submitting a petition to the government' to be one of the least effective as one of them felt "we're too small for the government to take notice" (IS, C, OS, M).

The student perspectives underlying this chart about less effective actions (Fig. 47) and their barriers to action are discussed at greater depth in the following sub-section, where ideas are consolidated into themes and sub-themes in the thematic map (see Figure 48).

The discussions of why certain citizenship actions were perceived as less effective than others revealed student elements of detachment, uncertainty and disconnection. These sentiments are captured in the themes 'I've become so numb' and 'wells of silence'.

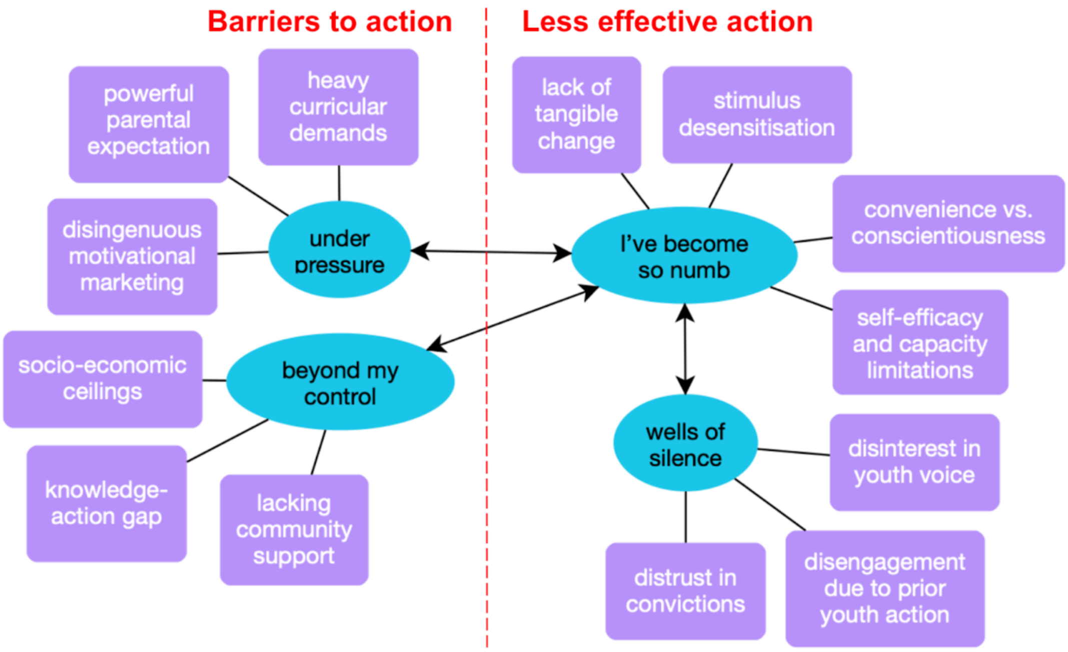


Figure 48: A thematic map of student perspectives about barriers to action and less effective citizenship actions. Themes are in blue ovals, with sub-themes in purple boxes.

I've Become So Numb

The ideas embedded in this theme, linked to less effective actions, are about the elements that hinder pro-environmental behaviour. As described in earlier sections (in 1.3.2), not seeing tangible change as a result of actions is discouraging, which also connects to feelings of inadequacy. There is "uncertainty about impact, because, like, we're just small potatoes in, like, this whole world", reported a student (LS, Co, OS, M). Continuing, they expressed how there was a psychological struggle balancing convenience and desire while dealing with the realities of some pro-environmental actions because "sometimes environmentally friendly stuff are actually, like, more expensive". This particular "push factor from taking action" (LS, Co, OS, M) links to an issue of socio-economic ceilings, which is discussed within the theme 'beyond my control', later in this subsection.

As described in the previous section, there was the distinct impression that a photography exhibition about plastic pollution would not really affect change (see Figure 47). Despite the exhibition being able to provide "concrete evidence [about plastic pollution]… I don't think it drives people or motivates them to actively take action" (IS, Co, OS, M). While part of that doubt related to a lack of precise personal connection, as discussed earlier, students also suggested the medium of still photography had limited dynamism to secure one's attention in a lasting way, and that "maybe it can be cinematic exhibition" for added emotional and reflective impact (IS, C, OS, M). In addition, students seem to be saturated with information such that it may desensitise them and result in action paralysis to some degree. A student reflected how they've "been, like, bombarded 1000 times about ocean plastic pollution and, like, why, why am I not doing anything?" (LS, Co, OS, M). Motivation to do something in response to the reality of environmental challenges that youth face is complex. There seems to be judgement between young people about where along the spectrum of pro-environmental behaviour people are, and what that suggests about their sincerity to act. A group of students (IS, C, OS, F and M) shed light on phenomena where one's willingness to authentically take action is deflected to others via the convenient pathway of social media:

> *1: There's a big trend of, kind of, taking these pseudo-moralistic stances to, kind of, virtue signal to people that you're, like, taking action and supporting, when actually... they'd rather just defer blame on to someone else and they don't want to actually take any personal responsibility.*
>
> *2: Lots of that happens over social media. People are happy to post about what they are doing, but just doing it to show people that they are 'woke'.*
>
> *3: Yeah, they are performing.*
>
> *2: It's very our generation, like, with social media. It's not like any other generation.*
>
> *3: It allows for, like, you know, it get cuts people slack and allows them to do, like, the bare minimum for a lot of stuff.*

These overall concerns extend to the next theme about why some justice-oriented citizenship actions lack impact; students have a distrust in authority figures who give the impression of being disinterested in youth voice and disengaged with youth concerns.

Wells of Silence

This theme captures the idea that students generally feel unheard by those in distanced positions of power, like corporations and the Hong Kong government. This feeling of dismissal also manifests as distrust in the seemingly green actions on the part of corporations and the government, where students question whether the motivation is intrinsically about doing good for the environment or if the gestures are primarily for cost-saving or political gain. Actions, like lobbying or petitioning, seem insufficient in causing ripples in the large structures of powerful entities, because, as an international school student shared earlier, they felt rather ignored by government. Without acknowledgement or feedback, students suggest these actions to not be worthy of one's time and effort, as one student (IS, C, OS, M) asked:

> *When's the last time you've heard, like, a government suddenly making a change because they received a bunch of letters from someone or they received a petition with a million signatures? Like, they don't really care. Like everything on the internet just gets forgotten after a week anyways. So then why would they care about like a small petition… they can just, kind of, just ignore it.*

Older secondary students in particular referenced their scepticism of engaging with the Hong Kong government given the little impact of previous large-scale action like the protests of 2014 and 2019-2020. The lack of results from prior youth movements, seems to fuel the distrust of the effectiveness of this approach. One felt they were viewed "as just kids because like in Hong Kong… they don't really see us as, like, people, like, with actual thoughts" (IS, C, OS, F). Though some local school students noted the potential for wide-scale positive impact of actions carried out by corporations or government, they too expressed doubts whether they would be listened to, unless there were "1000s of students" who were vocal (LS, C, YS, M). International school students (IS, C, YS, M) exchanged similar impressions to those of local school students:

> *1: If it's just a random kid on the street, I don't think they'll [the adults] believe it [the students' message] that much.*
>
> *2: Well, um, technically, uh, adults don't really listen to children, but for example, like Greta [Thunberg, the climate activist], she had a whole bunch of children help her in, uh, proposing on something, and that worked. So maybe more numbers?*

Feelings of disenchantment were echoed by other students (IS, C, OS, M) who questioned the scale of positive impacts being made if others did not follow:

> *1: You can make a change.. you can do whatever, but one person cannot change or impact other people to… make a change. But, like the, big, big companies and if the big majority are not making the change, so it's like counteracting what one person is doing.*
>
> *2: Yeah, adding on to that, I think, most of the action we can take does not have that great of an effect on the environment when it's those industries that are the ones who, who have the, the greatest impact on it. Just… to start recycling for a year [as an individual], sure, it's good. But does it really help the environment that much when they're big industries who have factories [and] they don't use renewable resources?*

These structural and systemic obstacles perceived by students return in student discussions about the barriers they feel when considering taking some form of citizenship action, topics covered in the following themes of 'beyond my control' and 'under pressure'.

Beyond my control

This theme considers the arenas where students felt somewhat powerless to engage in certain pro-environmental behaviour, despite being willing. One aspect is about not knowing how to take action in the first place and feeling uncertain about how to find such information out. This notion links back to the knowledge-action gap and how students lack sufficient education about local actions (see Ch. 6.1.2), something an international school student who had lived in Hong Kong for less than 6 months agreed with: "I don't really know about the rules here in Hong Kong, so I'm not really sure how exactly it [taking pro-environmental action] is supposed to work" (IS, C, YS, F). Much of what students are taught about solutions to environmental issues, especially for international school students, remains at the global level, which seems to be reflected in how local school students have greater accuracy about local environmental information than international school students as reported in Chapter 5.4.2).

Another challenge is the reality that, as teenagers, they have limited access to more expensive goods and services carrying greener labels, as mentioned in an earlier theme ('I've become so numb'). This may be an obstacle because 67.9% of students declared on their post-surveys to be 'somewhat likely' or 'highly likely' to participate in the green economy (see Figure 49). This attitude was equally found across local school students (68.1%) and international school students (67.8%).

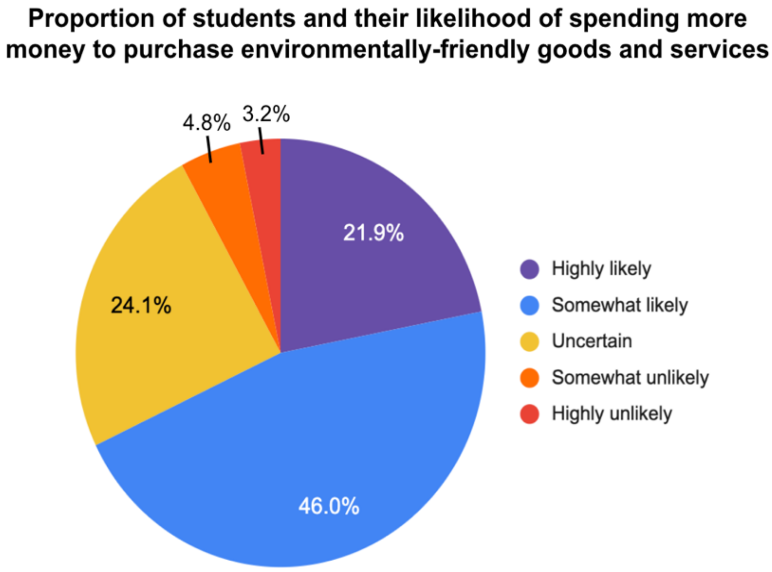


Figure 49: A pie-chart showing how the majority of students (67.9% of 187 surveyed students) were willing to spend a little more money to practice environmentally-friendly consumerism. A total of eight percent of students responded they were 'somewhat unlikely'.

Students often expressed there was a lack of community support, be it from friends, family or the wider society, which acts as a significant obstacle to initiate or continue with citizenship actions as an individual. Some students endured loneliness, "I do it, but nobody join me" (LS, C, YS, M), and dismissal mixed with fear, where one student described feeling "a bit scared sometimes… friends, like, they might… not look at you… they might say something that, that is not positive" (LS, Co, OS, M). Another expressed how "I see a few like-minded students who are motivated to go out [take pro-environmental action], but I don't see any huge governmental efforts to improve the situation, which is quite annoying" (IS, Co, OS, M). This phenomenon was also interpreted by students with regards to local waste management infrastructure, where a student questioned the productivity of the Hong Kong recycling system; "I heard the news said some recycling bin was not really go to the recycling… some is goes to the rubbish… to landfills" (LS, C, YS, M). When the very systems that aim to address an environmental problem are not trusted, it discourages students from participating.

Under Pressure

This theme conveys how students feel burdened to participate in citizenship action, despite caring about environmental issues. The sub-themes are related to the stresses of student life and being labelled as future decision-makers.

Students referred to their immediate experiences as secondary school students within the highly competitive Hong Kong education culture as a significant constraint to taking citizenship action. Specifically, the lack of time was commonly mentioned due to the heavy curricular demands. Despite final assessments being more than five months away, a student explained, "we're, like, really focused on exam stuff right now, so there isn't really that much time" to engage in pro-environmental behaviours (IS, C, OS, F). There were recurring impressions of how "you have to sacrifice your time" (IS, C, OS, F) to take action, and that attending school means "we have a lot of things [to do]... have stress" (LS, C, YS, M).

Parental pressure to focus on academic performance was another concern some students shared, stating that when "your parents are saying "you're wasting time, don't do it"... that's opposite of support and you'll feel discouraged" (IS, C, YS, M). The inverse pressure to be actively involved in taking citizenship action comes from messaging that students often receive about being the 'future decision-makers', often from teachers or media. These calls to action put "a lot of pressure on the young generation, especially because… we're going to [be] the future doctors, politicians, where we're going to be the ones living here" (IS, Co, OS, M). Though seemingly motivational, students found that type of communication somewhat false given that they aren't the generation to cause much of the world's current environmental problems (see Ch. 6.1.2, and the teacher perspective of this idea in Ch. 7.1.2).

Students exchanged many views about what makes citizenship actions challenging to do and amidst these discussions, they revealed what was needed to break some of those barriers to encourage greater participation in pro-environmental citizenship action.

7.2.4 Encouraging Citizenship Action

To counter many of the difficulties mentioned in earlier sub-sections about less effective actions and the barriers to act, students focused on the personal and societal networks as spaces for support. The theme 'stand by me' captures the idea that students need to feel bolstered by their immediate community, feel the benefits of intrinsic and extrinsic rewards, and feel valued for their contributions (see Figure 50).

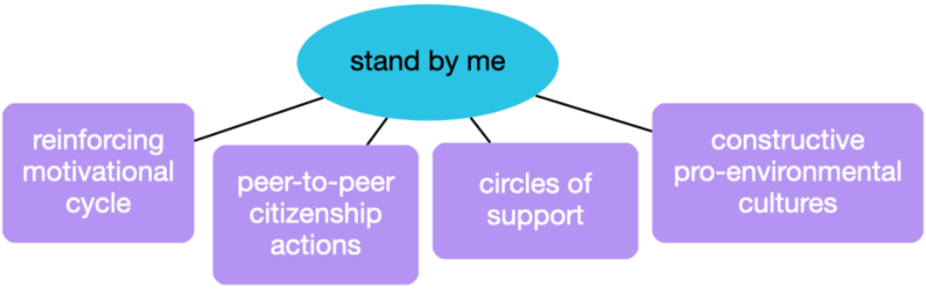


Figure 50: A thematic map of student perspectives about encouraging action. Themes are in blue ovals, with sub-themes in purple boxes.

The ways to help students take action is by making them feel positive, useful and championed in their pro-environmental endeavours. The layers move from the individual student, their personal circle of friends and family, and the wider school community. A student (IS, C, OS, F) proposed the positive feedback loop of taking action and being increasingly propelled to do more:

> *Every time I take some kind of action for the environment or I take part in some student-led initiative or I organise something... Basically, every time I do something towards, like, helping more sustainable future or preserving nature, it adds a little bit to my own personal motivation. So after every experience, I'm a little bit motivated to have another experience. So it's like a cycle that motivates me more.*

For some older secondary students, this type of intrinsic reward sufficed. Younger secondary students suggested benefits in the form of bonuses towards their academic achievements, for example a teacher could "give you more marks if you do the three Rs [reduce, reuse, recycle]" (LS, C, YS, M). Additional benefits can come in the form of how one is seen and supported by the social network that they are a part of. "Taking action makes you feel like a better family to people, [and] they'll respect you more", shared one student (IS, C, YS, M), while their classmate (IS, C, YS, F) remarked that "if it's like, my friend or somebody I trust, then I would definitely try" to take pro-environmental action. The influence of others is a powerful factor that another student felt drove them to act because it showed that "I'm not, like, the only one who cares… a lot of people are caring! So, this encourages me more to make an impact" (IS, C, YS, M). Having a supportive community is important for constructive learning on how to take effective action, as "we learn from… the mistakes that we made" (LS, C, YS, M).

These aspects provide very tangible implications for educational institutions to nurture pro-environmental citizenship within their students. The notions expressed here are suggestions to enhance the quality of the environmental education students experience, which connects back to what students felt the goals of environmental education should be, as revealed in themes, a 'guiding light' and 'emotions at the helm' in section 7.2.2, earlier in this chapter.

7.3 Citizen Science Organiser Perspectives

In this section, I report on the citizen science organisers' impressions about effective citizenship action, what barriers they thought students may feel towards taking action, and how to encourage students to take action. Their responses have been synthesised into two themes: 'the scalpel or the band aid' and 'power to the people', as shown with their associated sub-themes in Figure 51.

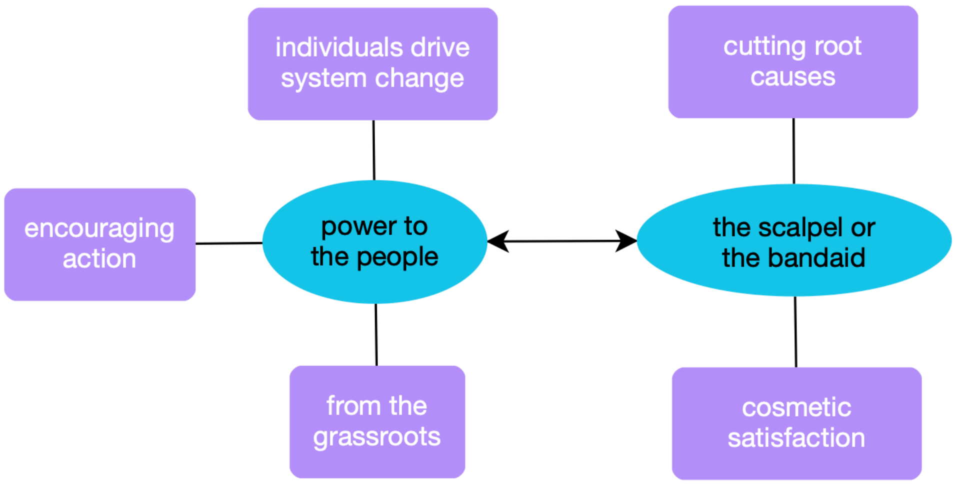


Figure 51: A thematic map of citizen science organiser perspectives about citizenship action. Themes are in blue ovals, with sub-themes in purple boxes.

The Scalpel or the Bandaid

This theme considers the approach to evaluating how effective different citizenship actions are. The 'scalpel' alludes to the strategies that change the system by cutting out the root causes, while the 'band aid' touches upon the idea of solutions that give a satisfactory impression of impact, though only at a surface level.

Citizen science organisers seem to primarily evaluate the effectiveness of citizenship actions around whether or not there would be positive, durable change regarding the particular environmental issue. This translated to some of the more effective citizenship actions, chosen from the same list that teacher and students had, to be the justice-oriented actions. In particular, 'discussing community issues with local district councillors' and 'submitting a petition to the government' were viewed as actions that, if successful, would lead to lasting change because they dealt with addressing the root causes. One organiser with experience in dealing with various environmental governmental departments has "seen that the government is not.. well, they are not completely deaf anyway, right, and to be honest, they have a lot of power, right, a lot of power to make a difference" (S-U, Co). Another organiser felt the opposite and suggested that petitioning the government and lobbying corporations would not lead to any tangible impact because "they have different priorities" and are "not always listening" (NGO, Co).

Citizen science organisers did acknowledge the value of particular ‘personally responsible’ and ‘participatory’ citizenship actions, namely the 'sorting of household waste for recycling' and 'hosting a photography exhibition highlighting local plastic waste'. A way to address a root cause of marine pollution and change how the currently wasteful system operates is by the habitual practice of sorting waste (S-U, Co):

> *I think sorting household waste is by far the most important, I know from the system standpoint, one of the biggest issues is literally sorting waste. It's so silly, but this one thing could literally change the way the cycle works, it's one of the biggest, biggest problems, ummm, and yeah, it's shocking how big of an issue this is. It prevents so much stuff from getting into landfills, no contamination. It's just so basic, but it has such a huge impact.*

Another organiser justified their choice of the photography exhibition as a more effective actions, pointing to the learning that comes from organising such an event in the first place (NGO, C):

> *You need a lot of preparation before that [the photography exhibition], so throughout the process, you get into the projects and that's how you get involved and understand the issues more deeply. Okay. Then that eventually hoping to help to change the mind and, and further actions.*

The same citizenship action was considered by the two organisers who supported co-created citizen science projects to be one of the least effective actions because the exhibition was likely preaching to the choir who are already quite informed. The outcome of such a visual representation of the plastic pollution problem may not necessarily lead to any action if people aren't aware of how to address the underlying causes of the issue in the first place. One of them (S-U, Co) conveyed how:

When we were at the HK Maritime Museum, I saw an exhibition on plastic pollution. It was really great, really moving, really beautiful. The catch is this: everyone knows about plastic pollution, there's nobody that doesn't know about plastic pollution and having more pictures, I don't think it is improving awareness, per say, to be honest, at this point, right? It doesn't make sense. I think it's a great way for people to express their personal contribution to this, but I don't think in the grand scheme of things, I don't think it is making a lot of difference because people mostly know that this is an issue. I think the issue is they don't know where the system breaks, but they know plastic pollution is an issue.

The less effective actions ranked by the citizen science organisers were based on impressions that some actions, though meaningful for those involved, lead to little overall change. 'Joining a beach clean-up' was one such action because of the re-emergence of coastal pollution requiring regular attention. Though an organiser valued actions that were "measurable… tangible… doable" (NGO, Co) and taking away bags of trash from a beach looked good on the surface, that action alone would do little to stem the influx of future debris. Until the root causes of waste management system and over-consumerism are addressed, actions like beach clean-ups would be a "great engagement tool, but in the grand scheme of things, I don't know how much of a difference it would make" (S-U, Co).

Power to the People

This theme relates to the ways in which the citizen science organisers feel that citizenship action can be encouraged and that barriers to act are reduced. From their experiences of working with students, the citizen science organisers felt that the lack of time, access and support were key obstacles students faced. To counter these challenges, the citizen science organisers explained how lowering the barriers to entry for taking action, and providing close-knit and wider community support would be consequential.

Citizen science organisers described knowing if one's actions make a difference as an influential factor spurring one to engage in pro-environmental behaviour. One organiser proposed, from a student's point of view, that "if I know I do something and that's how much impact I could bring in", then the efforts would be worthwhile (NGO, C). This sentiment highlighted the importance of predicting and seeing that one's actions delivers quantifiable change and how it may be a driver for future and on-going environmental action.

Another aspect is equipping the students with the support needed to encourage taking action about issues that matter to them. One level is within their immediate communities, family, friends and school, while the other amongst is the wider society and system. Students would benefit from having "the school acknowledge it in terms of policy changes, or have the community acknowledge it, that the students are doing excellent work for the community" (NGO, C). Another citizen science organiser said how vital it was to "create a bottom-up approach from the local community to the government" to create sustainable change (NGO, Co). Companies should play a significant role in this regard, as another co-created citizen science organiser declared that "business should be a force for good" (S-U, Co). They also pointed to the power of networks to assist the individual in bringing about systemic change, which linked back to their perspective of addressing the root causes of the environmental issues:

> *One of the biggest challenges is you need an intermediary, to push people to start doing that [taking action]. To answer questions, uhhh, to act as a support system, a supporting intermediary is really important. Umm, systems… I mean, this is a very perspective thing, irrespective of the system, each individual should be just doing their own bit, and if you do your own bit then the system changes.*

7.4 Comparing Perspectives

Earlier diagrams about the effectiveness of citizenship actions had the data grouped into teachers or students separately. The following diagrams reveal the comparison of citizenship action effectiveness between all combined teachers and all combined students (see Figure 52and Figure 53). I weave the perspectives of the four citizen science organisers between the teacher and student impressions in the following comparative analysis.

'Discussing community issues with local district councillors' had the highest support from all students (52.9% of total) as a more effective action, while 72.7% of the teachers agreed that 'hosting a photography exhibition highlighting plastic pollution' was more effective (see Figure 52).

How students, teachers and citizen science organisers defined 'effectiveness' had some notable differences and a few similarities. Whether the actions provided authentic learning experiences was the most consistent criteria for effectiveness from the teachers' and some of the citizen science organisers' views. This was part of the rationale for many teachers and a citizen science organiser in choosing the photography exhibition as more effective because it would require the student to learn about the plastic pollution issue at depth to curate it. Whereas the same action was considered by 41.3% of students and two of the citizen science organisers to be one of the least effective actions. Exhibitions like these are often carried out by environmental governmental agencies, and though they "encourage interest from the public… it has limited impact" (NGO, Co). They acknowledged how seeing the visuals could have an emotionally-powerful effect, however without an explicit call to action that was relevant to their lives and habits, the 'out-of-sight, out-of-mind' phenomenon may be at play.

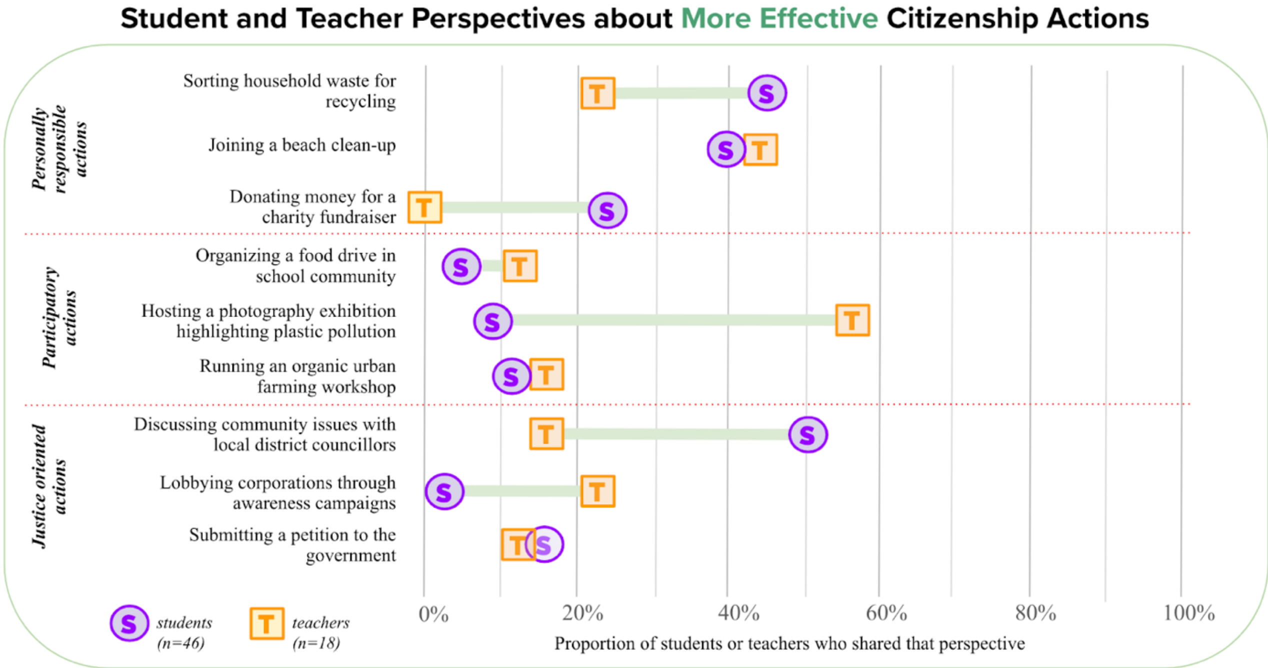


Figure 52: A comparison of all students and all teachers for actions they think are more effective.

One of the most significant criteria students based effectiveness on was if their voices would be heard by those with power to focus greater resources at the problem (e.g. local district councillors). They made a distinction between what they implied as the more accessible local district councillors and the distant socio-political entities like corporations and the Hong Kong government. Feeling unheard, unseen and underestimated by adults in power, 56.5% and 39.1% of students felt reaching out to corporations and the government, respectively, to be the least effective actions. Teachers were generally doubtful of the impact of efforts to address the problems at their roots, especially if it involved the Hong Kong government (see Figure 53), though there may be other factors influencing teachers' perspectives, as mentioned in Chapter 7.1.3. The citizen science organisers felt it key to participate in actions with impact on the fundamental causes of the environmental issues and identified the range of justice-oriented actions as more effective. They believed these approaches would have a wider-reaching impact if changes were made from the top-down. There was support from 22.2% of teachers who believed the justice-oriented action of 'lobbying corporations through awareness campaigns' would be effective for the same reasons (see Figure 52).

Student and Teacher Perspectives about Less Effective Citizenship Actions

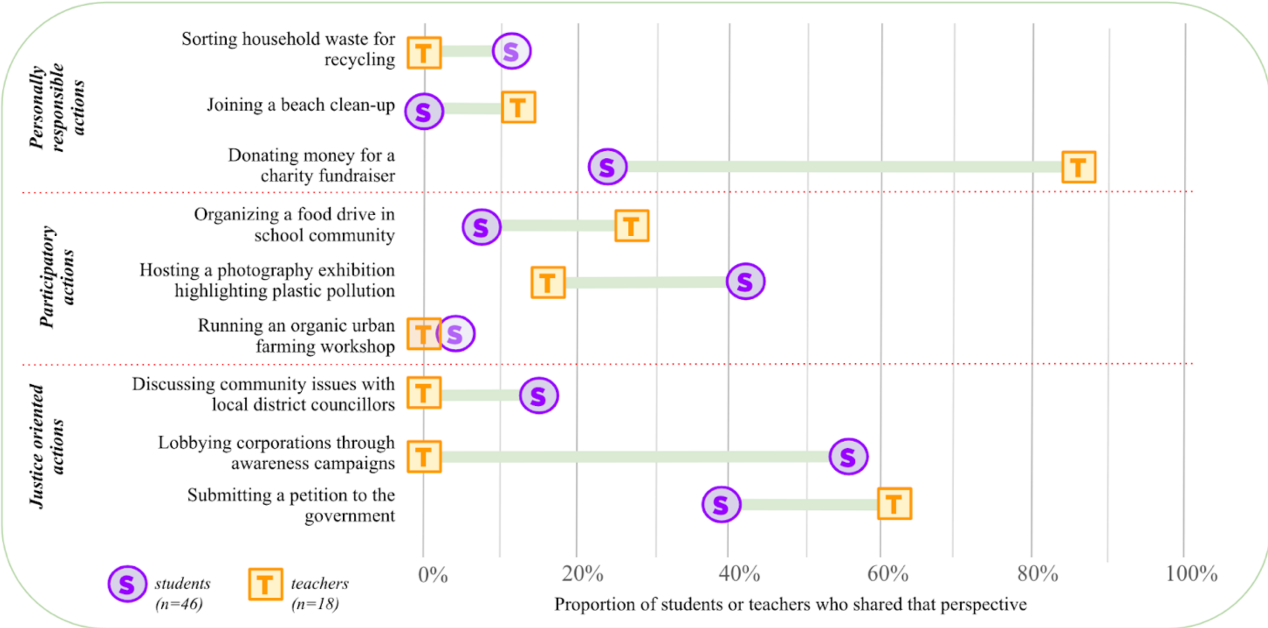


Figure 53: A comparison of all students and all teachers for actions they think are less effective.

A citizen science organiser and 45.7% of students felt 'sorting household waste for recycling' to be a more effective action, which 22.2% of teachers agreed with. Though there are some reservations about the efficiency of the system, as shared in the theme 'beyond my control' in section 7.2.3, this relates to the earlier point about students viewing personally responsible citizenship actions as effective because of their hands-on nature and low barrier to participate. An organiser recognised how not all the complex underlying causes of the pollution problem would be solved by this action, but sorting household waste for recycling would be straight-forward and practical start.

Students felt it important to be able to tangibly assess one's impact when determining effectiveness. They never mentioned citizenship actions as a learning experience to improve one's knowledge or skills about the issue. Out of the seven influential psychological factors for environmental behaviour, 'having the skills to take pro-environmental citizenship action' was the least influential factor for students, regardless of age or school type (see Figure 41 and Figure 42). As a result, there was a general pattern of consensus amongst students in finding the personally responsible actions more effective. Students seem to associate effectiveness of actions as seeing or feeling some measurable difference because of their efforts, e.g. a cleaner beach with full garbage bags as evidence of the trash they collected. 'Donating money to a charity fundraiser' was supported by 23.9% of students as one of the more effective actions (see Figure 52), while 83.3% of teachers felt the opposite (see Figure 53). This action was consistently labelled as an ineffective action by teachers because of the limited student engagement with the environmental issue and the focus on extrinsic material incentives to entice student participation. However, charities, from the perspectives of students, were generally better placed to address the issue because they had greater resources, expertise and wisdom, and community support. Students alluded to lacking these particular attributes. As such, they explained how providing charities with financial support to do what they do best, was a more sensible approach and an effective allocation of their efforts.

'Joining a beach clean-up' was one of the few actions students and teachers felt similarly about, at 39.1% and 44.4%, respectively (see Figure 52), and they considered clearing beaches of trash to be more effective because of the visual and quantifiable difference one's effort makes. As previously discussed, some teachers (see Ch. 6.1) and students (see Ch. 6.2) noted that the underlying causes were not being tackled in such an activity, and therefore its effectiveness had limitations. Yet, as one teacher reflected, "I tried to explicitly emphasise that you may not see the fruits of your labour immediately, or at all. But the trying is important" (IS, C, Lang)

7.5 Chapter Summary

In this chapter I reported the various perspectives that teachers, students and citizen science organisers shared about citizenship action and pro-environmental behaviour. Ideas that were common across the three participant groups included the value of participating in hands-on actions where one could see their impact and addressing the fundamental causes of the issue. They all acknowledged how a lack of time and community support was perceived as a barrier to engage in pro-environmental behaviours. While there was shared hesitation that some personally responsible actions would not address many of the root causes of particular issues, like beach clean-ups and plastic pollution, those behaviours still have an impact and are worth doing.

Divergent ideas, especially between teachers and students, centred around defining what effective actions are and the justifications for their perceptions. A key difference was how teachers viewed more effective actions as ones where students could learn about the issue the most, whereas students considered the main criteria for effectiveness to be whether their actions led to a positive impact to solve the issue.

There was also a difference about which psychological factors were more influential for initiating action between the younger (11 - 14 years old) and older (15 - 19 years old) secondary school students. Citizen science organisers had perspectives that sometimes aligned with teachers and sometimes with students, which could be because they were quite diverse in their professional work, experiences with citizen science as well as age. The overall findings represented in this chapter are synthesised further in the next chapter, the Discussion, where the most intriguing results about the impact of citizen science and the perspectives of teachers, students and citizen science organisers will be contextualised amidst wider research.

CHAPTER 8

8 Discussion

8.1 Introduction

In this chapter, I focus on the key findings from my study which make meaningful contributions to knowledge about citizen science, environmental education and citizenship action. I discuss these in-depth insights in the context of their wider research literatures and, where appropriate, consider how my methods for data collection and broad and deep analysis may have influenced my interpretations. Where my results align with more established understandings from prior research, I acknowledge those circumstances. My priority, however, is to examine the more unique findings that highlight the impact of school-based citizen science on students. There are two salient and overarching themes that underpin the influence of citizen science on student behaviours and the teacher, student and citizen science organiser perspectives about citizen science, environmental education and taking action: (i) 'nurture in nature' for 'nurture of nature', and (ii) where the education system breaks. In the latter part of this chapter, I offer a critique and an amendment to the modified environmental behaviour framework I adapted from Barr and Gilg (2007) as a theoretical contribution to the field of environmental behaviour psychology.

8.2 Did Citizen Science Experiences Lead to any Change?

Just as citizen science as an approach to collect environmental information has grown, so have the claims about its potential for transformative change amongst project participants (Bela et al, 2016; Jordan et al., 2012; Tauginienė et al., 2020). Creating new knowledge, developing environmental understanding and skills, and ultimately empowering participants to apply project findings to address the environmental issues of concern are some commonly hoped for outcomes of citizen science initiatives (Bela et al. 2016; Ruiz-Mallén et al. 2016; Turrini et al. 2018). Yet tangible support for these claims, especially about if and how citizen science can encourage action in youth, is limited. My study exploring the impact of citizen science experiences on how students feel, think and act towards the natural environment does provide some evidence in response to this under-explored question. Pre-survey, post-survey, field observation and interview results presented in Chapters 5, 6 and 7 detailed the many environmental behavioural variables that had a positive or negative shift after students experienced their citizen science projects. This section provides commentary on the significance of the most salient findings about the impact of citizen science on youth values, attitudes, knowledge and, ultimately, their pro-environmental behaviours.

8.2.1 Positive Change after Citizen Science Experiences

Consistent with studies showing increased knowledge after their citizen science experiences (Evans et al., 2005; Stepenuck & Green, 2015; Williams et al, 2021), my study demonstrates that Hong Kong secondary school students also have gains about environmental information, especially about local Hong Kong facts. The increases, especially in local knowledge, were greater for those participating in contributory citizen science projects compared with co-created projects, and for older secondary school students compared with the younger secondary students (see Ch. 5.4.3 and Ch. 5.4.4). Results from the regression analysis conducted on post-survey data showed that knowledge was not a statistically significant variable with influence on self-reported pro-environmental behaviour, which aligns with research that shows limited connection between the two variables (Ballard et al., 2017; Grossberndt et al., 2021). While some other research shows large positive changes in project-specific knowledge, the statistically significant knowledge improvements in my study were constrained by the small number of local (four items) and global knowledge (two items) questions. It was challenging to create a fair and accessible set of common questions that would be appropriate for students from 12 to 19 years of age for both local and international school contexts. However, as this part of the survey had individual question time limits of 30 seconds each (to discourage participants from searching potential answers online), it may have added pressure on students when they offered their responses, affecting their knowledge accuracy. Balancing the need for weighty quantity and quality of data with participant experience, I was conscious of keeping the completion time for the entire survey to under 20 minutes. Participants who fully completed the surveys spent, on average, 16.6 minutes for the pre-survey and 15 minutes on the post-survey.

Many studies measuring impact of citizen science have adult participants (Brossard et al., 2005; Dean et al., 2018; Haywood et al., 2016; Toomey & Domroese, 2013). This makes my research focus on youth citizenship action distinct because it is an understudied enquiry when evaluating citizen science project outcomes. My findings about increased self-reported pro-environmental behaviour supports evidence from previous investigations that found some post-citizen science participant actions (Ballard et al., 2017; Dean et al., 2018; Haywood et al., 2016; Robinson et al., 2021). Though specific actions differed between investigations, they often were about communicating project data and outcomes to the community, raising awareness, having a willingness to take pro-environmental action, and engaging in further knowledge-building on digital citizen science platforms. An aspect where my approach differed from such studies was that I inquired about behavioural intention and self-reported behaviour. My measurement for behavioural change was based on a 5-point frequency Likert scale and for a range of 10 common youth actions that ranged across Westheimer and Kahne's (2004) personally-responsible, participatory and justice-oriented types of citizenship actions, and Berger Kaye's (2010) direct, indirect, research and advocacy action groups. Behaviours with statistically significant increase included all the citizenship action categories and service learning action groups, providing evidence of the wide effect citizen science experiences have on participant behaviour afterwards. Though Kenyon et al. (2020) used Westheimer and Kahne’s (2004) constructs to analyse university student behaviours as part of a teacher education course enquiry project with citizen science, there is currently no research at the intersection of school-based citizen science and global citizenship education using Westheimer and Kahne’s (2004) and Kaye’s (2010) action nomenclatures. As such, investigating the kinds of actions citizen science could have an impact on could be a future avenue of research.

A strength of my study was the comparison of impact on pro-environmental behaviours between contributory and co-created citizen science experiences. Based on the probability of superiority statistic, co-created citizen science projects would likely lead to 75% of participating youth doing more pro-environmental behaviours compared with contributory citizen science projects which would only likely lead to 57% of those participating increasing their pro-environmental actions. Despite this promising finding that adds fuel to arguments for greater youth voice in project design, implementation, analysis and/or dissemination (Kermish-Allen et al., 2019), my sample sizes between the two groups was very skewed. Given the little experience Hong Kong teachers had with citizen science, most of those in my study opted to join the contributory projects requiring less time and effort to carry out. Though the findings for such a small number of participants in co-created citizen science projects ($n = 13$) were statistically significant, there are still limitations about the generalizability of those findings given how much larger the sample size for contributory citizen science project participants were in my study ($n = 174$). Ideally when making such evaluations, comparative research would have a more balanced representation of participants between different types of citizen science projects. This would first involve investing in greater support for teachers to carry out such demanding co-created citizen science projects in terms of time and resources from school leadership and citizen science organisers alike.

Another instance where there was a skew in participant sample size was when comparing younger and older secondary school students, despite statistically significant findings about increases in pro-environmental behaviour in the sample as a whole. The 15 - 19 year old participants (older secondary, $n = 63$) had an average 10.1% increase in behaviours, whereas there was no statistically significant change for the 11 - 14 year old participants (younger secondary, $n = 124$). Perhaps the time engaging in and with nature during their respective citizen science projects developed their 'personal values and attitudes about the environment', which was the most influential psychological factor on behaviour identified by the older secondary school students during interviews (see Chapter 7.1.2.1). As younger secondary school students had a smaller increase in knowledge compared with their older counterparts

(16.8% vs. 26.8%), their lack of statistically significant change for behaviour after a citizen science experience may relate to how during interviews, the 11 - 14 year olds found 'knowledge about environmental issues' to be most influential on encouraging them to act. These distinctions suggest the need for differentiated support for younger and older secondary school students to have greater effect on pro-environmental behaviour.

8.2.2 Negative Change after Citizen Science Experiences

My study found a very small decline in already high preservation values amongst youth after their experience with citizen science, which contrasts with other research about experiential environmental education (Bogner et al., 2015; Liu & Chen, 2019; Pan & Hsu, 2020). These studies have shown increased environmental concern or a decrease in the perception of using and modifying nature, though many are evaluating a full-day or multi-day programme, whereas 87.2% of participants in my study had less than 1 hour of an environmental education experience doing citizen science. My result was dominated by a decline in the item P3, "refusing to use single-use plastic items (straws, take-away plastic cutlery, plastic grocery bags) is a useful way to take action about reducing waste". The question was part of a five item suite of questions inquiring how youth feel about protecting nature and was one half of the preservation and utilization environmental values scale adapted from the Ecological Attitudes Scale (Bogner & Wiseman, 1999, 2006) and the Nature Relatedness Scale (Nisbet et al., 2009). Though the Cronbach alpha of the preservation values part of the survey was strongest with all the five items (0.76), P3 may not accurately capture the essence of participant feelings towards nature. It may be more a reflection of how participants perceive this particular action's lack of effectiveness as a solution in light of seeing the scale of the issue after their citizen science experience, rather than their values to preserve the natural environment. Of the 187 students, 89.8% of them saw or likely saw plastic pollution during their citizen science experience. Another possibility could be that as this study was conducted when Covid-19 caused an increase in single-use plastic use in Hong Kong, this reality may have caused a priority shift to champion health over environmental impacts (Cheung et al., 2020).

Despite attempts by the Hong Kong Government's Environmental Protection Department to promote a 'Use Less, Waste Less' lifestyle in their "Reduce and Recycle 2.0" campaign (HKSAR Press Release, 2020) near the beginning of the Covid-19 pandemic, there has been a doubling of take-away packaging and plastic waste in 2021 (Cheung et al., 2020; Ho, 2021), which questions the impact of such campaigns. In the commercial sector, while big corporations may try to change practices, they are met with some customer resistance: though McDonalds began their "No Straw Everyday" campaign in late 2019, customers still requested them likely due to habit, and the fast-food establishment placed trays of straws next to empty straw dispensers to deal with the demand (Chan, 2019). These incidents speak to the conflicted relationship Hong Kong people have with taking action that does more good rather than harm to the environment. Youth in Hong Kong are knowledgeable about various environmental issues, but are still asking about what practical actions they can take which can tangibly lead to positive change (Chung & Choi, 2021). These sentiments echo the perspectives reported by students in my study about having the information but lacking the knowledge to carry out pro-environmental behaviours with measurable impact (see Ch. 7.2.3 and the "Beyond my control" theme in Ch. 7.2.4).

Another case where my result has differed from that of others was regarding confidence in self-efficacy skills to address an environmental issue. A small decline in participant confidence after their respective citizen science experiences in my study may speak to youth impressions of difficulty in addressing the issue after noting its scope and complexity, as similarly seen with the decline in preservation values above. Manzanal et al. (1999) proposed how the complexity of an ecological system may overwhelm youth with information overload and may negatively influence one's ability to solve environmental problems. It may also be that such a short experience with a citizen science initiative may not be enough to instil greater confidence in one's skills to respond to an environmental problem. This understandably differs from findings of strengthened confidence in youth self-efficacy perceptions after a two-week environmental experience (Barnett et al., 2011). Similarly, a prolonged exposure with active nature-based experiences positively influenced self-efficacy (Korfiatis & Petrou, 2021) albeit in primary school youth. Though they did not measure impact of an environmental education programme, Meinhold and Malkus (2005) study of American adolescents showed how perceived self-efficacy was correlated with pro-environmental behaviour though not a predictor of it, a similar finding in my study of Hong Kong youth. On the whole however, there are few studies that assess impacts of environmental experiences on youth perceptions of self-efficacy, so the overall tendency may currently be inconclusive.

8.2.3 'Nurture *in* Nature' for 'Nurture *of* Nature'

This most salient theme introduces the idea that experiences in natural environments provide the kindling to spur students to take pro-environmental action. This interpretation was based on multiple linear regression analyses performed on the survey data and the in-depth reflexive thematic analyses of interview data. The key factors that led to increased frequency and range of self-reported pro-environmental behaviours in students after their citizen science experiences were their (i) personal experiences in nature and environmental centres, (ii) perceived connection to nature, (iii) frequency of environmental discussions in the home, and (iv) observations of pro-environmental actions done by people they knew, and awareness of positive actions shared on social media.

8.2.3.1 Experiences in Nature

It is an important finding that time spent in nature and in environmental centres had the largest influence on self-reported behaviours after students' experiences with citizen science. Interestingly it was the personal trips into natural environments and environmental centres that were influential on behaviours of the overall sample of students. This was also consistent regardless of school type, citizen science project type, school level and gender of the students. An insightful distinction was how school field trips in nature were especially influential for local school students in performing pro-environmental behaviours after a citizen science project. Given that local school students reported five times fewer experiences of school-organised field trips than international school students, it suggests how consequential experiential education is for them. It is significant to note that during the data collection period from November 2020 to July 2021, the Covid-19 conditions in Hong Kong prompted all the schools participating in contributory citizen science projects to discontinue any field trips off campus, and the two schools doing co-created citizen science projects were given special permission to engage in the citizen science experience off campus. This created a quasi-control situation to measure the impact of an experiential learning activity like citizen science, because students were not exposed to any other opportunity between their pre and post-surveys.

A study about field-based environmental education with Hong Kong local school students found that youth valued going to places they had not been to before and they saw it as an important aspect in their engagement and interest to be out in nature with their classmates (Ma, 2016). This could invite questions about the role of novelty (Dean et al., 2018) and the nature of specific learning outcomes in experiential education opportunities. Citizen science, being a relatively new approach in teaching and learning across Hong Kong schools, may feel more innovative and be more impressionable on youth. Though international school students report more frequent field trips as part of their formal education, it is their non-school experiences in nature and environmental centres that seems to most influence taking pro-environmental behaviours. Many citizen science projects are constructed for interested individuals to participate at their convenience, so once youth are aware of these kinds of initiatives through school, they could continue their involvement with citizen science projects in their own time. Projects that invite longer-term monitoring in natural surroundings and make clear the value of youth making observations, have positively impacted how some youth apply their citizen science learning to further their own enquiries using science (Robinson et al., 2021). The LEARN CitSci research team have created a multi-stakeholder guide with evidence-based recommendations about how to support more impactful citizen science experience on youth learning (Robinson et al., 2021), with some of their studied projects involving experiences in nature (for example, BioBlitzes or iNaturalist).

These findings about experiences in natural environments also align with insights from Chawla's research showing the value of casual time spent in nature as a major driver of one's environmental consciousness (Chawla, 1999, 2009). Additionally, Derr's 2020 review of various studies investigating factors that predict pro-environmental behaviour all point towards childhood experiences in nature-based activities, often alongside family and/or friends, being significant. While many studies that used the 'significant life experiences' approach found similar factors of time in nature developing environmental sensitivity and greater commitment to environmental issues, most of these studies were done with adult populations (Chawla, 1999; Furihata et al. 2007; Hsu, 2009; Palmer et al., 1998). There are some studies conducted with adolescents (Müller et al. 2009; Stern et al. 2008), though few amongst secondary school students in Asia (Pan & Hsu, 2020), so my research findings add to a nascent body of research reporting how experiences in natural environments are important in bringing about pro-environmental behavioural change in youth.

Additionally, the duration of time spent in nature differed, between those students who participated in contributory citizen science projects versus those doing co-created citizen science projects, and this had an influence on the extent of pro-environmental behaviour change. Co-created citizen science projects varied from an intense 2-day experience to 1-day experiences intermittently over nine months, while all contributory citizen science participants had less than one hour in nature (see Table 16). Students who spent more time in nature (doing co-created citizen science), were more likely to engage in more frequent pro-environmental behaviours.

Stern et al. (2008) also found that longer environmental education experiences had lasting positive impact on self-reported behaviours of teenagers. Increased levels of environmental stewardship in their post-surveys, administered after the final activity reveal short term influence. Longer term impact, determined by a follow-up survey 90 days later, suggested continued positive increases in awareness and self-reported pro-environmental behaviours.

Despite planning for similar follow-up surveys in my study, Hong Kong Covid-19 school closures shifted school timetables, which meant time between pre-test and post-tests varied from 1 to 80 days and may have contributed to the pre-survey and post-survey attrition rate of 55.8%. There were 423 students who fully completed the pre-survey and 266 who fully completed the post-surveys, which finally led to 187 paired sets of data (as 79 participants did not do the pre-survey). This may have been a result of a school year in flux with prolonged online schooling creating digital technology fatigue, which could decrease engagement from participants (Ebardo et al., 2021). Given the Covid-19 related challenges teachers and students were facing during the 2020-2021 school year, I opted not to carry out follow-up surveys because I anticipated even higher attrition rates with students doing exams, graduating and school holidays. The few follow-up survey responses would likely come from the more environmentally eager participants, likely producing a skew in the results.

8.2.3.2 Nature Preservation Values and Nature Connectedness

Frequency and range of self-reported pro-environmental behaviours were influenced by students' values to preserve nature. The statistically significant finding was most affected by the strong responses to one of the five preservation value items, the P4 statement "my connection to nature is an important part of who I am". This was especially the case for the female students in my study, whose pro-environmental behaviours were significantly influenced by their nature-connectedness. Despite a slight decrease in already strong values to preserve nature after their citizen science experiences (see Chapters 5.4.1 and 8.2.2), all students' pro-environmental behaviours were significantly influenced by their connection to nature. This finding broadly corroborates prior research conducted with primary and secondary school students.

While my study involved secondary school students, Cheng and Monroe (2012) also found how connection to nature was a most influential variable to influence American fourth-graders' interest in nature-based activities and environmental practices. Despite the age and cultural differences, their findings also validate the experience of Taiwanese adolescents, whose connection with nature was linked to the identification of personal pro-environmental behaviours (Tseng & Wang, 2020). While European senior secondary school students in Müller et al. (2009)'s research found that contact with nature did not influence pro-environmental commitment, their American counterparts reported that their connection to nature did influence taking some pro-environmental behaviours (Hoover, 2020). A comprehensive study to evaluate a new scale to measure nature connectedness conducted in the U.K. suggested a relationship between participants' strong connection with nature and behaviours, however this was somewhat variable for children and adolescents in the study (Richardson et al., 2019). Interestingly, a pioneering study considering the relationship between character strengths and nature relatedness by Merino et al. (2020) revealed how intellectual strengths (appreciation of beauty, curiosity, love of learning and zest) correlated most strongly with one's connection to nature. Though these intellectual strengths are not explicitly worded in the P4 statement, "my connection to nature is an important part of who I am", there may be elements of these traits embedded within how a Hong Kong student interprets and defines their relationship with nature. As a result, this key finding has important implications for the further development of such connections with nature in an environmental education context in Hong Kong schools.

8.2.3.3 Household and Social Influence on Environmental Awareness and Behaviour

The actions youth observe their family members take have an influence on their own behaviours towards the environment. The six items in the household experiences portion of the survey ranged from practising greener household consumptive behaviours (like bringing one's own shopping bag and buying energy-saving electronic goods) to sorting household waste (an activity commonly reported by students during interviews), yet it was "Discuss environmental issues" that statistically influenced youth pro-environmental behaviour. The pro-environmental behaviour of male students in my study was particularly influenced by this out of all green household activities. This overall finding may be explained by the limited involvement youth have in decision-making at home or about the acquisition of household electronic equipment (more of an adult task because they have the disposable income). One in six families in Hong Kong employ household help to assist in tasks like grocery shopping and dealing with household cleaning (Ng, 2021), which may reduce the likelihood that youth participate in actions like buying goods or sorting waste. This then leaves discussing environmental issues as the most likely opportunity for student interaction with family members. Such discourse is a more overt practice that may signal an openness to behaviours that nurture environmental concern and action.

This explanation finds support from a Danish study of older secondary school students and their parents, that identified how the greater the visibility of parental pro-environmental actions, the greater the impression on their children to act pro-environmentally (Grønhøj & Thøgersen, 2012). The researchers found a greater correlation between a child's behaviour and their parents' behaviours, than between a child's behaviour and their parents' attitudes, suggesting that youth learn more from what they see in practice rather than what they can infer. This supports the powerful position of parents as active role-models to encourage youth to act favourably towards the natural environment. In a local study, social influence as measured by conversations about environmental issues with parents, teachers and friends, was found to positively influence self-reported pro-environmental actions by Hong Kong adolescents (Lee, 2011). Taken together, my study's findings have consequential implications for teachers and other trusted adults whom students observe frequently in an educational setting.

At the same time, Barr and Gilg (2011) have raised uncertainties about the efficacy of green household actions and its broader influence on pro-environmental behaviours, especially when challenging the modern consumptive systems we live in. Their U.K.-based research with adults highlighted how the home is viewed as a convenient place to demonstrate pro-environmental behaviour and more sustainable lifestyle changes. I recognise the potential difference between adolescent and adult behaviours given varying mindsets, experiences, and quite importantly, decision-making about household consumption. My study methodology included students, but not their parents, which could have provided a more robust picture about the potential influence of pro-environmental behaviour within the household. Adding the adult dimension about the behaviours in the home would supplement the information from the youth perspectives and perhaps address the limitation that self-reported behaviours are often inflated compared with observed pro-environmental behaviours (Kormos & Gifford, 2014; So et al., 2021). Thus, questions remain about how effectively these habitual actions can prompt further environmentally-mindful acts (Barr & Gilg, 2007).

Given the result that the influence of others guides behaviour, what students see others do has an impact on their own actions. Whether it comes from hearing stories on social media or observing people they know take pro-environmental action, these positive references have an influence on students' self-reported pro-environmental behaviours. This was a consistent finding regardless of school type, citizen science project type and gender. Interestingly where this differed slightly was between younger and older secondary school students, whereby the 12 - 14 year olds were prompted to act when seeing environmentally harmful activity (as well as social media stories about positive action). The older secondary school students were more significantly influenced by the positive actions. The latter finding tangentially reflects Ojala's (2015) research about the interplay of hope and youth engagement in environmental issues amongst Swedish senior secondary students. Her study demonstrates a link between action competence and constructive hope, whereby having a more hopeful and positive outlook related to greater pro-environmental behaviours in youth.

Although slightly out of bounds of my current research, there is additionally an intriguing idea about environmental and science identity development and its relationship with pro-environmental behaviour. I mention this here because it connects with research into pro-environmental behaviour and I return to this notion in the further research section of my Conclusion (see Ch. 9.3.3). A study of Belgian preadolescents participating in an experimental study were either given or not given an 'eco-label' before completing a survey about their pro-environmental behaviours and the results showed higher levels of self-reported environmental action for those given an ‘eco-label’, also evident in a follow-up survey a week later (Charry & Parguel, 2019). The authors identified an ideal 'age window' for this type of environmental nudging to be after the age of 10, when children start to develop the concept and sense of an identity. Bridging this idea with citizen science is a nascent area of research, and though Williams et al. (2021) found no evidence of impact on youth science identity after a citizen science project, Ballard et al. (2018) did report some aspects of such growth and recommended further appreciation of social and cultural histories as part of one's identity development. Researchers of a collaborative multi-year and multi-citizen science project study also involving youth, reported development of scientific knowledge, agency and environmental science identify, especially if engagement can be over longer periods of time with supportive facilitation (Robinson et al., 2021). Thus, it would be an angle worth exploring as a participant observing coastal biodiversity in my study felt that they personally exhibited traits of a scientist at work (see 'No lab, no coat, no problem' theme in Chapter 6.2.2). There are currently no studies that examine an Asian context for the growth of an environmental or science identity amidst citizen science experiences, so further exploration of this direction is warranted.

8.3 Where the Education System Breaks

This other most salient theme exposes the facets of environmental education and/or citizen science that, despite all good intentions, are constraining the ability to address the value-action gap in Hong Kong youth. Specifically, these aspects touch upon the following: (i) the limitations of a highly prescribed and discipline-bounded curriculum; (ii) the disconnect in perceptions about prompting youth agency, and (iii) the lack of how-to knowledge about engaging in more collective, justice-oriented actions to spark systemic pro-environmental change. These findings were derived from the thorough analyses of semi-structured interviews with 18 teachers and 46 students across the eight participating schools, and four citizen science organisers.

Local and international school teachers and students unanimously pointed to time and content pressures within their respective curricula. These constraints impact the investigative depth and breadth about environmental issues, and how students engage with said issues from a learning and action perspective. Teachers admitted that a lack of time to meet the many learning objectives limited how extensively they could teach about any particular environmental problem and a citizen science organiser identified how students lacked holistic knowledge about the complexity of environmental issues. This shortcoming may relate to the students having noted the minimal to no opportunities for reflections to aid in the learning about what was observed during the students' citizen science projects. Unfortunately, it is not a new issue as environmental education has had very slow uptake and attention across the local and most international curricula in Hong Kong as it is rarely an examined subject (Stimpson, 1994). These constraints still persist as shared by Ma's (2016) investigation across local schools, where teachers shared a lack of resources, knowledge, experience and even confidence, to do environmental and experiential education justice in their lessons. A key component of impactful experiential learning is the value of reflection, otherwise without it, the learning is fragmented, the enquiry is stifled and the potential for application of one's new-found knowledge is minimised (Dewey, 1938; Simms, 2017). These obstacles are structural and bound by prescribed exam-driven curricula for local schools (HKDSE) and in senior levels of international schools (GCSE, IGCSE, A-Levels and IBDP). Furthermore, as environmental education is usually embedded within another course like science or geography, the focus of the environmental issue being investigated is often hooked to the discipline. This compounds the challenge for students to examine the relationships and interdependencies within environmental issues with wider social, economic and political lenses.

Even when teachers do bring in elements of systems thinking and interdisciplinary learning about environmental problems, students highlighted how the real-world connections ground their learning, but do little to activate personal citizenship action. Calabrese Barton (2012) cautions that unless there is conscious design in experiential education pedagogy to support youth to lead and co-create their learning rooted in their critical sense of place, educational institutions are missing an opportunity for significant reform in science education and society. With a shared and constructivist theory approach to learning to build more opportunities for youth to exercise agency, teachers believed that engagement increases and achievements improve (Basu & Calabrese Barton, 2010; Schusler and Krasny, 2015). In particular, students in my study noted the impact of connecting the issue to their own lives and habits, thereby making the learning personally relevant (see 'Me, myself and I' theme in chapter 7.1.2.2). Relevance is a notion that has connects to one's links to place, and roots new learning amidst a personal framework for understanding (see Ch. 2.1.1), thus giving an experiential activity like citizen science, value (see Ch. 2.2.5). That sentiment about personal relevance was echoed in a recent participatory action research study about climate change education and activism conducted by Hong Kong local and international secondary school students and their teachers, and university students (Safaya et al., 2021). The students identified the significance of making explicit the connections between the environmental issue and their own lives through habits and actions (be it positive or negative). In addition, there was a strong message from youth about how they are not equipped with the knowledge or experience to go beyond doing "recycling and the basic stuff" (Safaya et al., 2021, p. 30) and required more support from their community to feel that their contributions would have an impact. A 'Youth Speak' opinion piece in the "Youth Hong Kong" magazine, published by Hong Kong's oldest and largest organisation for youth groups, by Chung and Choi (2021) also mentioned that environmental education is currently rather disjointed and does little to champion behavioural change. Based on their experiences of studying in Hong Kong, they suggested overcoming the 'nature deficiency' that Hong Kong youth typically have, because of a highly urbanised lifestyle, by spending more time in nature through experiential and outdoor education, which fully supports my findings discussed earlier about one of the most meaningful running themes across my quantitative and qualitative findings (see ''Nurture in Nature' for 'Nurture of Nature'' theme in Ch. 8.2.3).

A fundamental barrier for students to take action is linked to their perception that despite the call to be the future actors for positive environmental change, the more consistent message they hear from their parents and teachers is a focus on achieving strong academic results. In essence, this creates a conflict whereby taking action is seen as more of an 'add-on' or, as one teacher posed, "is this an extra thing for me to do?" (IS, C, Sci), rather than a key objective of environmental education, by both students and teachers. Students commonly held the view that the goal of environmental education was to apply their knowledge to take purposeful action, which was a perspective shared by some teachers and citizen science organisers. In contrast, Courtenay-Hall and Rogers (2002) find influencing behaviour as part of environmental education philosophically at odds with pedagogical approaches that champion critical thinking and more constructive ways of learning. Yet in the Hong Kong circumstance, students reported expecting transformational outcomes from their environmental education that inform their actions and behaviour towards the natural environment. The local Hong Kong curriculum guidelines state that a fundamental goal of environmental education is to support students to take tangible action for the environment (Curriculum Development Council, 1999). Despite the published objective being applied for more than two decades, the Education Bureau's Environmental Report 2020 reported that out of the approximately 550,000 students in Hong Kong local schools, only 1% took part in the School Environmental Protection Ambassador Scheme and only 1.5% joined the Outdoor Education Camp Scheme (Education Bureau, 2021). These low participation rates within the environmental education schemes provided by the Education Bureau reveal significant opportunities for improvement at not only the school, but also at the policy level.

For reasons similar to those I stated earlier, Ma (2019) and Jackson et al. (2016) summarised many of the obstacles being faced by Hong Kong teachers to implement those guidelines fully, resulting in limited alignment between theory and practice in teaching about, in and for the environment in schools. Additionally, with some students in my study reporting feeling saturated by the message that they are the future leaders and decision-makers to positively affect the environment, the pressure may contribute to their anxiety, and they are not automatically encouraged to take action when the burden is placed on them by the very generation that had more to do with creating the problems in the first place (see theme, “A guiding light” in Ch. 6.1.2). “We’re still students... we don’t have much impact on the world”, expressed by a Hong Kong student involved in participatory action research about climate change education and activism, captures this pessimism (Safaya et al., 2020, p. 30). Eco-anxiety has been a concern for Hong Kong youth and balancing emotions with positive frames of mind along with a sense of hope are key strategies to counter the negative stressful feeling (Ng, 2020).

Student-teacher dissonance became increasingly evident when development of student agency was examined. Teachers pointed to the importance of having knowledge about an environmental issue and having a strong emotional reaction to an environmental stimulus during experiential learning opportunities as key factors that would spur students to take action. Though students also felt that having an understanding about the environmental issue could lead to more appropriate actions being taken, the impact of an emotional trigger is temporary and may not have as much of an effect on their pro-environmental behaviour because there are additional barriers that stifle their ability to act. As shared during student interviews reported earlier (see "I've become so numb" theme in Ch. 7.1.2.3), there is a risk that too many emotional hits could lead to desensitisation and action paralysis. Studies have reported about the affective angle of youth engagement with various issues like climate change and its significance in dealing with environmental anxiety (Pickard, 2021; Trott, 2021). Much of their findings show how when youth take collective action, it helps to manage their negative feelings of fear, anger or sadness about the issue, and shift their emotional paradigm to one of more constructive hope (Ojala, 2015). Yet, for Hong Kong youth, they do not find the typical actions they are supported in undertaking, like recycling and doing beach clean-ups, really address the underlying issues, which brings in a layer of scepticism about the impact of their actions. Nor are there guidelines for teachers to better support their students in dealing with their emotional responses to channel it into positive outcomes and having access to such resources is a key implication in Baker et al. (2020)'s study with parents and teachers, to neutralise the doom and gloom messaging that youth often receive in school lessons and media.

Another malalignment between teacher and student perspectives is about where the impact is happening. Teachers are more concerned with what the students learn when taking action rather than whether those actions led to any positive change about the environmental issue in question. An example of this way of thinking was how teachers overwhelmingly saw 'donating to charities' as a disengaged way of taking action as engagement need not require much understanding about the environmental issue being supported nor have an active, hands-on component. This is in direct contrast with the student viewpoint, as one of the influential driving forces for them to participate in pro-environmental behaviour is to have a meaningful impact on the issue that concerns them. This psychological factor was one of the top three most influential on youth taking action across all the age groups in the study. Many students saw donating to charities as an effective way to contribute financially when they could not necessarily contribute with their own actions because of a lack of experience or know-how. No student ever mentioned the educational angle or any learning outcomes from taking action as part of the beneficial impact. This may be since teachers, by the very nature of their profession, are tuned to evaluating experiences from an educational perspective. Therefore, this finding distinguishes the differing priorities for teachers and students, which leads to important implications for educational institutions that promote environmental education and student agency. It also calls for teachers and schools to reflect on outcomes of environmental education.

Linking to this idea of what students find impactful actions to warrant their time and effort is the reality that they are usually only treating symptoms rather than the disease. Students most commonly engage in personally-responsible types of pro-environmental behaviours because they are easy to do (see 'low-hanging fruit' theme in Ch. 7.1) since, for example, campus waste recycling and beach clean-ups are often initiated by their schools. There were less justice-oriented actions being taken, despite students declaring how these would be some of the more effective ways to systemically address the issue. Their view aligns with those of Courtenay-Hall and Rogers (2002) whereby those specific types of actions, categorised as indirect action in their paper, is key to shifting from bandaid actions to providing real solutions to the problem. Taking action to address root causes of issues is more challenging to carry out and may even be at odds with the norms of the communities students may find themselves in. Though understanding individual behaviour change was a large part of my research, all participants acknowledged multiple factors at play when choosing to take pro-environmental action. The gap between which actions would be good to do and what actions are being done reflect some of the reported cognitive dilemmas and multi-faceted constraints that students felt. Spurling et al. (2013, p. 7) argue that some behavioural models "exaggerate the autonomy of individual choice" and suggest that an individual's action may reflect social practices rather than their pro-environmental values and attitudes, as there often are material, logistical or infrastructural constraints when making decisions. While this leads to greater complexity in behavioural models to appreciate the influence of such outside forces on individual behaviour (hence my adaptation of Barr and Gilg's (2007) framework that accounts for some of these variables), it does not disqualify the significance of one's actions in taking a stand to express their pro-environmental values and attitudes. As Mahatma Gandhi shared, "We need not wait to see what others do" (1964, vol. 12, p. 158), a notion that a younger international student agreed with (see “Emotions at the helm” theme in Ch. 6.1.2).

Students in my study explained that much of their inaction is not only a lack of time due to academic pressures, but also the lack of knowledge to tackle the issue in such a substantial way to practically affect positive change. This relates to a finding by Connell (1985) of primary and middle school students (up to Gr. 9, which overlaps with the ‘younger secondary’ students in my study) whereby students were reluctant to continue doing an action if they felt that succeeding or failing at it was out of their control. Recognising this obstacle means that schools have a tremendous opportunity within their community to demonstrate other creative and critically-responsive actions to address Westheimer and Kahne's (2004) category of justice-oriented actions and at the same time, develop a more critical approach to global citizenship education (Andreotti, 2006, 2014). Students have shared they want to know the specific ways to take action. Providing students with a ‘how-to’ guide to take action may seem to be at odds with those who feel that doing so, would atrophy one’s creative and critical thinking skills from lack of use. Andreotti (2014) and Bryan (2014) have challenged how the ‘soft’ citizenship approach, which could align more with Westheimer and Kahne’s (2004) ‘personally-responsible’ citizen, does little address the fundamental causes of the issues of concern. However, when considering the opportunities for students to reflect on their actions, evaluate the impact they have had on the issues they addressed, and subsequently use their new learning to determine what they would do differently to confront the underlying reasons of the problem, one could acknowledge the value of such a constructive, step-by-step approach for self-efficacy and agency. It is not necessarily mutually-exclusive to have support on how to take action and to deeply examine the ways in which one’s own actions or behaviour are part of the structural or systemic reasons for the issues faced, especially in an iterative and experiential learning context (see Ch. 2.1.3). Trott (2020) suggests how giving examples of what actions can be taken to address problems supports the development of youth agency and acts as a stepping stone for students to further develop their own plans for action.

The knowledge gap about consequential action is also prevalent amongst the teachers, as there were few who could explicitly relay the steps one would take to engage influential entities like local government bodies and corporations in addressing the various environmental issues. This finding is supported by Ma's (2016) Hong Kong-based research where he highlighted the need for greater professional development and resources for teachers to support youth empowerment. A similar concern was raised in environmental education research conducted with Canadian teachers by Simms (2017) and she offered additional solutions in the form of school community support and embedding citizen science in courses to provide opportunities to take action.

When brought together, all these findings have important implications for policy and practice regarding how to enhance how students engage with experiential environmental education in local and international schools in Hong Kong. These, along with directions for future research, will be introduced and discussed in the concluding chapter (see Ch. 9).

8.4 Modified Environmental Behaviour Framework: A Theoretical Contribution

Part of my original contribution to research within the intersection of citizen science, environmental education and environmental psychology is the novel use of a modified environmental behaviour framework to suit the Hong Kong educational context. In the following subsection I will evaluate the framework and offer suggestions for further development of its variables to suit experimental/quasi-experimental research conducted with youth about experiential environmental education and citizenship action.

8.4.1 How the Framework Fits this Study

The justification for using this particular modified framework is explained in detail in the literature review and methodology chapters (see Chapters. 3.2 and 4.3.1). During the quantitative data analysis process, this framework especially guided the exploration of influential variables on behavioural intention and behaviour (see Figure 54). Recognising how closely correlated behavioural intention and self-reported behaviour were and how intention would overshadow the influence of any other variables, the decision to solely focus on self-reported behaviour was made to allow for a more nuanced exploration of influential situational and psychological variables. As such, the framework could be simplified to remove the behavioural intention variable. With the emphasis on investigating potential differences based on school type, citizen science project type, school level and gender, these situational variables should remain as influential variables in the framework. There is always a concern that very complex models become too unwieldy and impractical to operationalise, while too simple a framework may not provide insights about what influences people to act pro-environmentally, therefore a balance must be struck (Kollmuss & Agyeman, 2002).

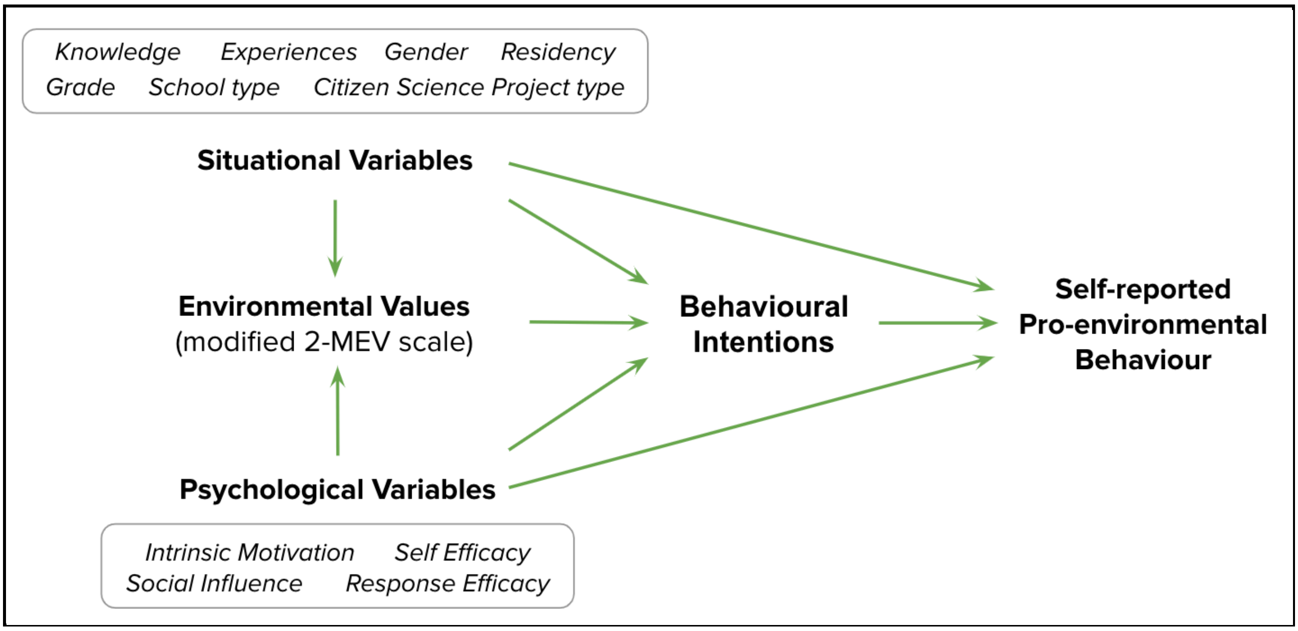


Figure 54: the modified framework I used to construct the quantitative instruments prior to collecting survey data from student participants.

The discussion throughout the bulk of this chapter brought to the fore potential allied lenses with which to more comprehensively examine what influences youth to take pro-environmental action, ones that could especially capture cultural signatures that have as yet to be incorporated in models. The additional facets of (i) one's environmental or science identity development, (ii) one's emotional state in response to environmental stimulus, and (iii) socio-cultural perspectives about taking action, could be incorporated into the framework either as lenses for comparative analysis or as influential variables. Though these elements may add complexity to the framework that could impinge on its usability and practicality, there is value in considering these features for research and practice. Bringing in aspects about environmental or science identity is useful for teachers to shape learning objectives towards such identity growth and associated self-efficacy or action competence development. Given the potential for these traits to have transformative impact on how youth experience citizen science (Ballard et al., 2018) or other environmental learning opportunities, it would be a valuable component to integrate. Similarly, with the recognition of growing environmental anxiety in youth, appreciating the affective dimension of environmental education would upskill teachers and students with tools to redirect the negative emotions into more constructive action and concern for the environment (Ojala, 2015, 2021; Richardson et al., 2019). Considering socio-cultural realities is valuable because meta-analyses of research in the 1990s show some differences amongst populations with more individualistic vs. collectivistic mindsets, whereby those latter cultures develop positive biospheric attitudes (Schultz, 2002). Though those findings are more than two decades old and globalisation may have created more cosmopolitan societies in urban areas, one's development in a socio-cultural atmosphere makes an impression (Feinstein & Waddington, 2020). Furthermore, socio-cultural contexts effect the development of values in society and these guide how such values are taught in educational settings (Brown et al., 2021).

I offer the updated framework (see Figure 55) acknowledging that while some nuance within environmental behavioural psychology have shifted compared to Barr and Gilg's (2007) original Environmental Behaviour Framework geared towards adult green consumer behaviour, this new version has practical pedagogical value for teachers as a tool to inform their environmental education practice. It can be used as a planning and evaluation device for experiential environmental activities, using a citizen science project as the core learning component.

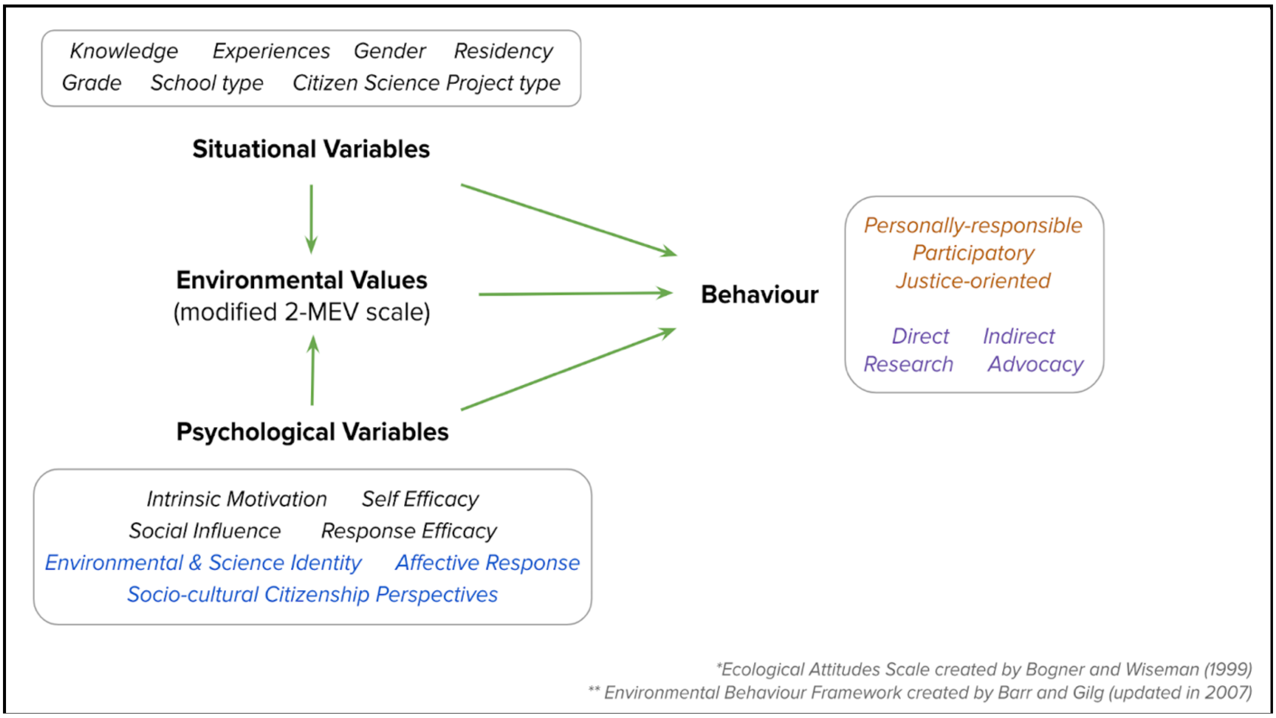


Figure 55: An updated version of the modified framework that incorporates my findings, the wider literature, while maintaining much of Barr and Gilg's (2007) frame and Bogner and Wiseman's (1999, 2006) scale.

8.5 Chapter Summary

In this chapter, I discuss the findings from my quantitative and qualitative data to understand the impacts of environmental citizen science in context of the wider literature about citizen science, environmental and global citizenship education, and environmental behaviour psychology. While my findings corroborated with results of previous studies about citizen science impacts on increasing topic-specific knowledge, the notable contribution from my research was the empirical evidence about greater self-reported pro-environmental behaviours after an environmental citizen science experience. Personal experiences in natural environments, field trips in nature and one’s connection to nature were found to have some of the strongest influences on taking environmental actions, which is supported by previous environmental education research, including studies from Asian contexts. Engaging in discussions about environmental issues, seeing others act and hearing about actions that positively affect the environment are also factors that influence behaviour, which links with research about the power of hope and agency to frame how youth deal with eco-anxiety. The two major themes, 'Nature *in* Nature for Nurture *of* Nature' and 'Where the Education System Breaks', summarise the important findings from the teacher, student and citizen science organiser perspectives about what they value from environmental education, their citizen science experiences and how to engage in citizenship action. These themes also provided a glimpse of the recommendations for enhancing the potential of experiential environmental experiences, like citizen science, to have an impact on how youth feel, think and act towards the natural environment. My critique of the Environmental Behaviour Framework I adapted for use in my study led to an offering of a new modified framework that incorporates additional concepts about the role of emotions, identity development and socio-cultural citizenship action on influencing pro-environmental behaviour.

CHAPTER 9

9 Conclusion

In this final chapter, I synthesise the results and novel findings of my research about the impact of citizen science experiences on how students feel, think and act towards the natural environment. The investigation sought the perspectives of teachers, students and citizen science organisers about their experiences of environmental education, citizen science and citizenship action. Citizen science, particularly those used in an educational setting, is understudied in the Asian context (see Chapters 2 and 3). By responding to each of the three sub-research questions I provide holistic answers to my overall research questions: (1) What is the impact of citizen science on environmental values, attitudes, knowledge and behaviours of Hong Kong students? and (2) What are the perspectives about environmental education, citizen science and citizenship action amongst teachers, students and citizen science organisers? While I shared some limitations regarding my interpretations of findings in the previous discussion chapter, I examine the methodological limitations here. My original contributions to the realms of citizen science, environmental education and citizenship education are offered as implications for policy and practice, especially appropriate for formal education settings. A key motivation to carry out this research was to glean practical pedagogical tools for enhancing how students experience environmental education, and my implications help to provide these. I close the thesis with a reflection on where future research concerned with creating transformative environmental education experiences with citizen science could go.

9.1 Overall Research Questions: Impact of Citizen Science on Hong Kong Students and Perspectives about Environmental Education, Citizen Science and Citizenship Action

9.1.1 What are the Changes in Student Environmental Values, Attitudes, Knowledge and Behaviours, after a Citizen Science Experience?

My research shows that environmental citizen science experiences do have an impact on how students feel, think and act towards nature. After their citizen science experiences, students exhibited increased local environmental knowledge and a greater frequency and range of pro-environmental behaviours. More specifically, older secondary school students and those who participated in co-created citizen science projects had a proportionally larger increase in their self-reported pro-environmental behaviours compared with students involved in contributory citizen science projects. A slight decrease was seen in already high values for nature preservation, though this may be a consequence of the particular question in the survey as explained in Chapter 8.2.2. Confidence in one's self-efficacy skills also showed a small decline, particularly for female students.

Citizen science experiences also had an impact on the psychological variables that influence students to take pro-environmental action. While behavioural intention was positively and moderately-to-highly correlated with self-reported behaviours, the most influential psychological factor on pro-environmental behaviour in students was one's personal experiences in nature or environmental centres. This was consistent across all variables of school type, citizen science project type, school level and gender. Importantly, students in local schools, despite having far fewer opportunities for experiential environmental education, were shaped more by school field trips in nature than their international school peers who were guided more by their own non-school initiated experiences in nature. The other statistically significant influential factors were one's preservation values in the form of one's connection to nature, household experiences partaking in pro-environmental behaviours, and the social influence of seeing environmentally-beneficial actions carried out by people they know and hearing such positive stories in the media. These findings provide empirical evidence towards the oft-made claims that citizen science has the potential for transformative impact on how youth learn about environmental issues and personally take action to address them.

9.1.2 What are Teacher, Student and Citizen Science Organiser Perspectives about Environmental Education and Citizen Science?

Teachers, students and citizen science organisers had varying levels of alignment in their perspectives about environmental education and citizen science. Teachers and students were in greater agreement about the value of experiential hand-on activities in environmental education, and saw citizen science as an effective and novel pedagogical approach to build curiosity, engage in relatable enquiry like a real scientist and participate in learning that had meaningful purpose beyond curriculum-driven educational outcomes. Where views differed were about the specific goals of environmental education, in particular about applying their learning to take impactful action. Students felt that developing motivation to act was not enough, but that there should be time and space in their learning activities to carry out pro-environmental actions, something that teachers and citizen science organisers did not explicitly state as part of their desired goals for environmental education. All three groups felt that citizen science was a valuable experiential approach that could meet many goals of environmental education, make scientific enquiry relatable and bring real-world purpose to a school-initiated project. Students engaged in contributory citizen science activities expressed a missed opportunity to feel a more profound effect because there were no reflections afterwards, something that teachers did not comment on. Citizen science organisers had hoped that teachers would initiate some post-citizen science lesson discourse but were uncertain about such follow-through given the workload teachers already have. Teachers and students both acknowledged the positive impact on knowledge, skills and pro-environmental behaviours that citizen science activities can prompt. Students and citizen science organisers commented that nature-based citizen science experiences play a role in developing nurturing values towards nature, a key finding from interviews that complements quantitative results from the survey data. Students alone recognised how participating in citizen science made them feel part of a like-minded community, which they saw as an enabling factor to take pro-environmental action.

9.1.3 What are Teacher, Student and Citizen Science Organiser Perspectives about Citizenship Action and Pro-Environmental Behaviour?

There was common ground in perspectives between teachers, students and citizen science organisers about effective actions being hands-on with tangible impact and ideally addressing root causes. Views diverged about how to measure effective impact: teachers and citizen science organisers were more concerned with what students learn when taking citizenship action, while students valued making a tangible positive difference on the environmental issue instead. Though all groups suggested experiences that prompt emotional responses to preserve nature could spur students to act, students revealed it as largely a temporary trigger. Participants reported that emotions could also work negatively to overwhelm students into action paralysis. Engaging with local-level authority figures and those more experienced in dealing with a specific environmental issue, like NGOs, were seen as more effective citizenship actions by students. On the other hand, teachers were more dismissive of gestures like donating to charities because it requires minimal effort by students to feel they have contributed. Younger local school students (11 - 14 years old) identified needing sufficient knowledge about an issue and prior experience taking action as influential factors to encourage pro-environmental behaviour, whereas younger international school students (11 - 14 years old) needed to feel that their action would make a noticeable difference first. Older secondary school students (15-19 years old), regardless of the type of school, expressed how their personal values, attitudes and motivations were their driving influences to initiate action.

Commonly acknowledged barriers to taking environmental citizenship action included the lack of time, feeling pressure to perform academically well and limited community support. Students emphasised that despite being knowledgeable about environmental issues, they lacked the know-how to go beyond the obvious ways to take pro-environmental action, like recycling and doing beach clean-ups. They expressly wanted to know what else they could do to address the underlying systemic causes of wicked environmental problems. The realm of opportunities for action revealed greater alignment between teachers, students and citizen science organisers. They noted the power of having a personal connection with an environmental issue, having an active role with a green mission in their school community, and a positive feedback loop of encouragement when taking action.

9.2 Limitations

This subsection addresses the aspects about my instruments and methods that limit how generalisable and credible my findings are. These revolve around the skewed demographics of my participants, the English and Cantonese language challenge, and the questions measuring environmental values and knowledge in the pre and post-surveys.

My research would have benefitted from a better balance of participants across grades, and from local and international secondary schools. The prevailing Covid-19 restrictions during the 2020-2021 academic year meant that several schools and their teaching staff declined invitations to participate in my research due to school-specific online learning and off-campus limitations. While I did have students from every grade level of secondary school, 66% came from grades 6 and 7. In Chapter 5.2 I mentioned how the skew came from teacher decisions about project links that suited their curriculum and interests. This exposes possible inequity of opportunities to embed citizen science in environmental education in Hong Kong schools. There were three local schools compared with five international schools in my study and the number of participants between the two types of schools was significantly skewed. In the paired surveys (n = 187), 73.8% of responses came from one international school doing a contributory citizen science project with students across grades 7 to 10. Much of the overall survey data analysis about impact of citizen science experiences would have been a reflection of these students' experiences. With 11.7% of the surveyed students, 28.3% of interviewed students and 33.3% of interviewed teachers coming from the three local schools, I acknowledge that these responses reveal their own unique circumstances and may only somewhat represent the experience of local school students and teachers across Hong Kong. Similarly, there were just five international schools participating, so I note that the student and teacher perspectives most accurately reflect their specific situations. Even though there were only eight schools participating in my study, they cover the main curriculum systems found in other schools in Hong Kong. In addition, the pool of potential schools was limited during dynamic Covid-19 restrictions in the 2020-2021 school year in part because of the limited familiarity with citizen science amongst teachers in Hong Kong. As citizen science gains popularity amongst the public with initiatives like the annual global City Nature Challenge every April, researchers conducting future studies about school-based citizen science may find more schools interested in participating. Therefore, a concerted effort should be made to involve a more equitable groups of student and teacher participants across grades, and local and international schools in future research.

During the student interviews, and especially those from local schools, I was conscious about my use of English as the main medium of conversation. Even though all schools, including the local schools, were using English as their primary mode of teaching and learning, there were students in my study with varying levels of comfort with the language. I was aware that there may be some confusion or misinterpretation of my questions and their responses may not have translated with the full nuance they wanted to share. To address my concern, I encouraged students to speak in Cantonese if they felt more comfortable than in English, and I sent the interview questions translated into traditional Chinese characters over Zoom's chat function live, as we were conversing. Only two students out of the 46 interviewed took advantage of these options, which suggests the majority felt confident enough to communicate with me in English. At the end of my interviews with local school students, I casually enquired why they volunteered to participate in the interviews, while so few of their schoolmates had; language skills was a major factor. Conducting group interviews with students using their non-native language can still lead to rich and engaged discussions, as youth often feed off each other's responses to fully sharing their perspectives (Ho, 2006). Still, I propose it vital to have a researcher with adequate multi-lingual skills or a research team that have complementary language skills in which to conduct interviews with multi-lingual participants.

As explained in the discussion chapter, measuring environmental values using my modified version of Bogner and Wiseman's (1999, 2006) 2-MEV scale led to an unexpected result that seemed somewhat contradictory. Having identified the particular question at the root of a decrease in preservation value, I speculate that P3 may not accurately measure students' values towards nature. To mirror the essence of the original 2-MEV scale, while adapting it for the Hong Kong youth context, I created the P3 question which may reflect one's sense of response-efficacy rather than one's values. As such, a deeper examination of questions across the numerous environmental scales needs to be considered when developing a set of questions about environmental value. In an ideal scenario with more time, a researcher could conduct some short semi-structured pilot interviews with Hong Kong youth about how they feel towards preserving and using nature, carry out thematic analysis to identify key themes, and then construct an environmental values survey to be used. Using a qualitative tool to inform a quantitative instrument may more accurately shed light about the Hong Kong youth context, and is seen as an advantage of a mixed-methods approach (Creswell & Garrett, 2008).

While wider research shows large positive changes in project-specific knowledge, the statistically significant improvements in knowledge within my study were constrained by the small number of local (four items) and global knowledge (two items) questions. It was challenging to create a fair and accessible set of common questions that would be appropriate for students from 11 to 19 years of age for both local and international school contexts, and to produce an instrument that was short enough to reduce the burden on participants. However, as this part of the survey had individual question time limits of 30 seconds each (to discourage participants from searching potential answers online), it may have added pressure on students when they offered their responses, affecting their knowledge accuracy. Juggling the need for valuable quantity and quality of data with participant experience, I was conscious of keeping the completion time for the entire survey to under 20 minutes. Participants who fully completed the surveys spent, on average, 16.6 minutes for the pre-survey and 15 minutes on the post-survey. Future researchers could always expand the knowledge questions to be more balanced between local and global questions, and comprehensively aligned with the content being learned in the citizen science projects, which would elongate the survey and potentially impact user experience and completion rates. To address those concerns, one could separately test knowledge on-site just before and just after the citizen science experience, given that this portion of the survey is much shorter, and these questions require quick information recall rather than reflection. The rest of the survey could be conducted some time before and after the citizen science project, as it was done in my study.

I discussed that a more robust study to measure impact would have a control group in addition to the groups receiving the citizen science experience in my Methodology (see Ch. 4.3.2), however it was not possible with the schools in my study. The common approach to ensure equity in teaching and learning opportunities meant that all students of a grade or subject would participate in the same activity. This is a feature of Hong Kong schools with common timetables and socio-cultural expectations for learning objectives and assessments. While designs to have the control group ultimately receive the activity after the data collection phase is complete addresses issues about equitable access to learning experiences, it is much harder to do this for an experiential learning engagement with additional logistical and planning components like citizen science. This was especially a barrier while Covid-19 was impacting how teachers and students were experiencing school, so I opted to reduce the barriers for entry into my research and accepted all willing schools.

9.3 Implications

A key driver for me to conduct this research was the hope of learning practical ways to address the environmental value-action gap by enhancing how I engage my students in environmental education. As such, this section is personally important because it boils down my study's most significant findings into real actions at the pedagogical, policy and research levels to strengthen transformative environmental education experiences using citizen science. I focus on the teachers, school administrators and citizen science organisers, before considering policy because my goal is to affect change in the more immediate time frame and within the current circumstances experienced in schools. As a teacher myself, I recognise where local and international school teachers have more freedom to enact ideas within our lessons and courses, with support from the school leadership. Such pedagogical choices can be implemented within weeks or months and would have tangible outcomes for students in the short term. On the other hand, changes to policy take much longer to see through to fruition, especially given the national and international range of curricula that exists across schools in Hong Kong.

9.3.1 Pedagogical Practice

The following implications are for teachers, school administrators and citizen science organisers, and span suggestions regarding influential experiential environmental education, impactful citizen science projects, and purposeful citizenship action and community involvement. Throughout, there are references to where the original 'Ten Principles of Citizen Science' (Robinson et al., 2018) could be modified to better serve the educational application of citizen science.

9.3.1.1 Teachers

Fundamentally, students need more time in natural environments and in environmental centres to develop their connection to nature. It would be extremely beneficial if teachers built more opportunities for nature-based experiences across their lessons. Ideally there could be a mix of formal learning activities and more casual experiences in natural environments, to prompt learning and wonder in students. Given the effects of household engagement in environmental issues on student pro-environmental action, teachers could also encourage their students and parents to take personal trips in nature and discuss environmental issues outside of school time. Regardless of how formal the experience in nature is (formal schooling or personal time), it needs to be explicitly clear to students how the state of the natural environment and the related environmental problems can connect to their lives and habits. One cannot assume students make the connections automatically, thus guided discussions and reflective activities are vital to establishing one's relationship with nature meaningfully.

One impactful way to provide transformative learning activities in nature is by incorporating the citizen science approach. As even short durations of one-off citizen science projects lead to positive changes in pro-environmental behaviour, teachers could consider embedding accessible contributory citizen science projects (like using 'iNaturalist' to investigate biodiversity) in lesson topics associated with nature. For greater impact on student behaviour, teachers could consider developing co-created citizen science projects with their students (and experts, if needed). Bringing the student and teacher viewpoint about which topics of inquiry matter touches upon the 2nd and 3rd principles of citizen science (see Table 2) by bringing the educational outcome and the drivers of the educational inquiry to the fore, rather than focusing on the scientist and their "genuine science outcome". In addition, with genuine student inquiry comes the confrontation that all the learning outcomes could not possibly be known beforehand, otherwise it would not be true inquiry. Thus, such a co-created project requires more time, suitable training and effort on the part of teachers, so they should be provided with tangible support (related to a suite of suggestions for school administrators in the next section). From the start, the projects' goals and objectives need to be clearly linked with students' interests and practices towards nature, so that they can better appreciate the impact of their actions on the environmental issue they are studying. This is especially key for co-created projects as the youth voice should be equally spearheading the direction of the citizen science investigation. A concerted effort in this regard challenges the forces behind the inquiry, and supports a more dynamic scaffolding of where learning by doing informs youth decision-making for action. Additionally, teachers should be forthright about the positive contribution of science and scientific enquiry to address complex environmental problems. No matter if a contributory or co-created type of citizen science project is used, the most important element after setting the stage and context of the project before embarking on it, is the post-activity discussion. As is good pedagogical practice from a constructivist approach, opportunities to reflect on one's experiences situates the learning in a more purposeful place; one from which students can transfer knowledge and skills to inform future behaviour.

The journey towards taking pro-environmental action just because one cares about nature is not a linear one. Contrary to some teachers' impressions, the value-action gap persists even when youth have an emotional reaction to environmental wrongs they have observed. Though it may seem instinctual to go from an emotional response to practical action, the majority of students need ideas and exact steps to transform their concern into pro-environmental behaviour. The teacher's role in supporting students to construct that bridge is key to students' developing self-efficacy and response-efficacy. Part of achieving this should involve opportunities for students to participate in collective change-making; in schools this can come in the form of having student roles in green groups, environmental clubs and multi-stakeholder committees that create environmental agendas with pragmatic outcomes. Teachers can encourage youth pro-environmental citizenship action by keeping in mind that younger students (11 - 14 years of age) want knowledge about the issue and the belief that their actions will make an observable difference, while the older secondary students (15 - 19 years of age) find their personal values and motivations spark action. Furthermore, teachers could channel the way they expose students to environmental issues with some differentiation: older secondary students mainly respond to positive stories and behaviours, while the younger secondary students react to narratives and gestures that depict both beneficial and harmful impacts on the natural environment. And lastly, teachers and students need to build common understandings about what effective citizenship action looks like. Given their contrasting perspectives, which I've discussed in previous chapters, having conversations about the differences between personally-responsible, participatory and justice-oriented actions, alongside opportunities for direct, indirect, research and advocacy types of actions, will allow for more aligned support for students to carry out a range of citizenship actions. These discussions are especially important for teachers who are involved with the service learning side of the curriculum and evaluate the volunteering, service or citizenship actions that students partake in as part of their school experiences. Even if some teachers may not directly be involved with environmental education, their support to their colleagues who are is vital for the actualization of such experiences during the school calendar.

9.3.1.2 School Administrators

The role of school administrators is extremely important for the successful implementation of initiatives in environmental education, including citizen science, and citizenship action. As administrators make decisions about educational priorities, design timetables, and approve field trips and events, they should be aware of how their work enables or creates barriers for teachers who want to drive environmental education at school. The following are key areas where administrators can help champion environmental education.

Developing one's connection to nature by providing opportunities to be in a natural environment is the springboard from which youth take action. As such, administrators need to provide space and flexibility in the school calendar and timetable for nature-based learning experiences. This is especially the case for local school administrators, as their students have a significant disparity when it comes to field trips and excursions, compared with international school students. Prioritising environmental education means supporting teachers with time and resources to design and carry out citizen science projects. Practical support could be in the form of having a member of the administration help with logistics like field trip risk assessments and transportation planning, while the teachers can focus on the educational planning. If the contributory or co-created citizen science projects and environmental excursions are interdisciplinarily rooted, then there is a greater need for administrative support to provide professional development training for inquiry-based experiential environmental pedagogy, collaborative teacher planning time and timetable flexibility. Additionally, school administrators with roles that expose them to members of the wider community with links to citizen science, research about the natural environment, innovations in environmental sustainability and the like, should act as a bridge to connect such outside expertise with their school staff. Making such links would also provide the administrators a wider pool from which to offer teacher and staff professional development about the importance and the development of an environmental education movement at their school. Involvement by school leadership also signals to their community how integral the initiatives are to their overall school mission and encourages more staff to follow suit.

Another facet of environmental education where administrators are crucial is with community building for collective action. For students to have a consequential avenue to voice their opinions and apply their knowledge from their environmental experiences, administrators need to include them in multi-stakeholder committees or create green groups where actionable decisions about the school are made. These committees could drive the creation of, for example, a school-specific environmental education vision and mission, or a green infrastructure, procurement and waste management strategy. With such tangible opportunity to affect change in their schools, students will feel increasingly supported, less sceptical about being greenwashed about seemingly green school initiatives and encouraged to continue such pro-environmental behaviour. Such student representation gives their peers and teachers greater confidence that positive systemic change is possible at the school level, which could transfer to the wider community involving NGOs, local government and corporations. The scalability of such experiences is fundamental in nurturing youth self-efficacy and response efficacy, the belief that they have the skills to take action and that their actions can have an impact.

9.3.1.3 Citizen Science Organisers

Organisers who want greater participation from schools in citizen science projects should appreciate the curricular objectives and teaching structures that teachers, and by extension their students, need to adhere to. To do this, organisers should study the landscape of experiential and environmental education in the curriculum documents used by local and international schools to identify opportunities to embed the citizen science project. Inviting professional teachers to share their opinions about how the project could be an impactful pedagogical tool would enhance the uptake of citizen science in an educational setting. This would also address a key criticism about who citizen science, a purported participatory approach for public good, serves. Ideally the teachers could be compensated for their time and/or receive certificates evidencing their contribution towards innovative pedagogy, which enriches their own resumes for professional advancement. As a result of this scoping work, organisers could create and host professional development sessions about embedding citizen science in schools, especially those which encourage being in nature. Additionally, developing easy-to-use guides for teachers and students to participate in a citizen science project with supporting resources (in print and digital formats) would lower the barriers for entry. This would encourage more schools to invest in learning and adopting a nascent pedagogical approach that has demonstrated positive impacts on knowledge and pro-environmental behaviours.

Citizen science organisers can enhance the outcomes of citizen science projects used in schools by making it clear to teachers and students what their contributions do for environmental research and how the findings inform actions to address environmental issues. Being topic-specific and aligning these messages to the students' lives or their interests, as much as possible, improves participant engagement. Offering to lead or co-facilitate post-citizen science debrief sessions with reflection activities would enhance their learning. A common call from students in my study was the need for more knowledge about how to specifically take actions that will make a meaningful difference. Creating a list of tangible and age-appropriate citizenship actions that link to the citizen science project objectives responds to that need. This list should include explanations about how those efforts practically tackle the environmental issue of concern. The actions could be categorised by common service learning terminology, for example Kaye's (2010) direct, indirect, research and advocacy actions. This provide teachers and students with a more holistic understanding of how citizen science can be a transformative method for teaching and learning in environmental education.

9.3.2 Policy

In Hong Kong, the Education Bureau is the department of the Hong Kong Special Administrative Region's government tasked with implementing education policies. Local schools follow the Hong Kong national curriculum, leading to the Diploma of Secondary Education (DSE) as set by the Curriculum Development Council, an advisory group in the Education Bureau. Though international schools follow their own accredited curricula (like GCSE, IGCSE, A-Levels, IBMYP and IBDP), they are still expected to incorporate some overarching policies by the Education Bureau that affect all educational institutions across the territory. With the knowledge that what teachers deliver is tethered to either local or international curricula, I offer ideas to enhance how environmental education is experienced by students at a policy level.

There is a great need to modernise the 1999 environmental education guidelines and make them relevant for today's understanding of environmental education pedagogy as well as the needs of current-day students and their school communities. I echo the call by Ma (2019) in their joint statement with academics, NGOs and educators concerned with the state of Hong Kong's environmental education that environmental education guidelines for schools need to be reviewed and updated. Though the guidelines suggest that topics about the connection between humans and nature are embedded in various subjects like Science, Geography, Social Studies, and Citizenship and Society, these elements are diluted and offer little in the form of a coherent environmental education curriculum. Furthermore, the focus is about learning 'about' the environment, rather than learning 'in' and 'for' the environment (Ma, 2016). This is key in light of findings that demonstrate effective strategies to engage and develop environmental knowledge, concern and action towards the natural environment. Learning about environmental issues is not enough, and it is the learning and nurturing of one's preservation values in nature to create a nurture for nature. This finding goes for teachers, as much as it does their students. There needs to be greater opportunity and access to teacher professional development in experiential environmental education. Teachers, especially those with less experience, need to be exposed to potential nature-based experiences in Hong Kong (or supported to explore such opportunities themselves) and be able to share good practice and current pedagogical strategies derived from practical research. Policies that prescribe recommendations for initial teacher education and teacher professional development should align with teacher-identified needs and implications from research with teacher participants. Training about using impactful experiential pedagogies, including the use of especially co-created citizen science, would be a marked step towards incorporating more innovative learning tools to develop youth agency. Thanks to initiatives like the UN SDGs and youth climate change movements, there is a growing focus on environmental issues that need to be translated into realistic measures. A top-down step that would have a long-lasting impact on youth engaging in pro-environmental behaviours would be for the Education Bureau to stipulate a minimum number of hours per year for students to be engaged in nature-based learning. This would propel school administrators to support their teaching staff in the design and implementation of such experiential learning activities because the Education Bureau has made it a priority.

Similarly for school administrators in providing ways to engage with the community to take action, the Education Bureau should provide schools with the access points to other government departments that are responsible for environmental issues across Hong Kong. Resources that share how to engage with departments like the Environmental Protection Department, Environmental Campaigns Committee, Environmental and Ecology Bureau, legislative councillors and district councillors would be instrumental in developing a youth citizenry that move beyond the personally-responsible to more justice-oriented citizenship actions. Without this, the barriers to participating in more pro-environmental behaviours that positively influence change at a systemic and structural level remain, a common frustration voiced by many students and teachers. An enlightened policy would supplement the suggestions for student exposure to nature along with ways in which to take action to preserve and conserve it.

9.3.3 Further Research

Based on the enduring questions as a result of my research and in the wider literature, the following are lines of enquiry that could be explored to augment our understanding of what motivates youth to enact their pro-environmental values influenced by their environmental citizen science activities.

My study fills gaps in the research about the cross-section of citizen science, environmental education and citizenship action in part because there is little exploration of the topic in Asia. As such, more research needs to be carried on the continent because of the potential differences in teacher, student and citizen science organiser perspectives about such experiences given the socio-economically and culturally diverse populations. Subsequently, a greater range of students attending schools of different national curricula should be involved in such studies because of the potential that such differing circumstances may influence their access and response to citizen science activities and eventually pro-environmental action. With citizen science gaining popularity as a pedagogical tool for enquiry and place-based education, research with schools using co-created citizen science approaches would offer tremendous insight about the value and impact of a more student-led design compared with the contributory citizen science projects. This further relates to the need to examine the impacts of shorter or one-off experiences that contributory citizen science projects often are used for in school settings, compared with those of the more complex and longer term co-created citizen science investigations.

Research instruments to measure environmental behaviour psychology, like the modified framework I proposed in Chapter 8.4.2, could also consider additional affective factors like environmental or science identity, to capture a more holistic picture of how youth go from assessing their pro-environmental values to their actions. Similarly, there is currently inconclusive research about the impact on and the role of the self-efficacy environmental psychology variable towards pro-environmental behaviour. To appreciate how any impact of citizen science changes with time, future studies would benefit from a quasi-experimental design that would include a follow-up after a period of 6 - 12 months (or the next school year). This would allow for greater confidence in the results about how citizen science experiences influence how students feel, think and act towards nature.

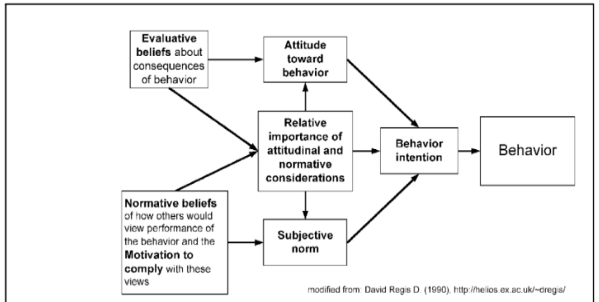
Bringing together findings across my study's most salient overarching themes of 'Nature in Nature for Nurture of Nature' and 'Where the educational system breaks', and the growing body of research about the use of citizen science in schools, a new set of principles of citizen science as a pedagogical tool would be an important contribution to the intersecting spaces of experiential and environmental education, citizen science, environmental behaviour psychology and citizenship education. These principles should reflect (i) the needs of increased educator and student-led educational outcomes, whether expected or developed during a citizen science inquiry experience; (ii) a reorientation about who drives the investigative process, especially when one considers for whom the inquiry is of greatest importance and value given their situated context; and importantly, (iii) for whom and how findings are applied to address issues of concern.

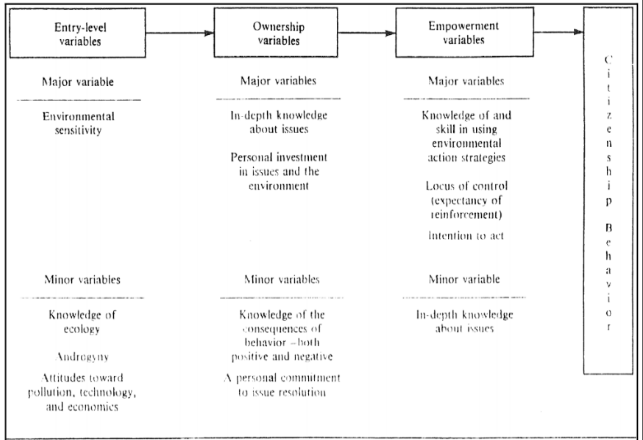
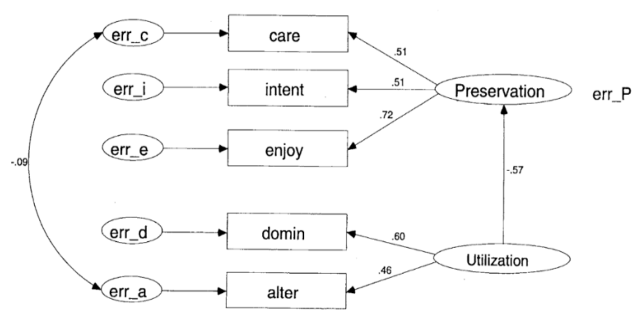
9.4 Researcher Next Steps

My experience conducting this substantial piece of work encourages me to explore even further. I have been fortunate to receive a Croucher Foundation Postdoctoral Fellowship to continue my pursuit of evaluating innovative pedagogical strategies to reduce the environmental value-action gap with citizen science. To carry out this research, I plan to incorporate more participatory approaches to fulfil a dual purpose: to offer more insights about this understudied realm, and to use it as a teaching and learning opportunity with the schools and participants. These aims link back to my original goal to influence praxis in environmental education. This is how I exercise my agency to improve pedagogy.

APPENDIX A - Behaviour Psychology Frameworks Summary

This large table with diagrams is what I made to summarise the different frameworks in behavioural and environmental behaviour psychology in order to differentiate between them and decide on the most appropriate framework for use in my study.

Theory / Model	Authors (Date)	Application / Use	Theory summary & ideas	Supporting studies	Critiquing studies
Expectancy theory of motivation	Vroom (1964)	Social, industrial and organizational psychology	• Valence **x** instrumentality **x** expectancy ⇒ motivational force • Valence = attractiveness of a particular outcome • Instrumentality = idea that more effort leads to greater likelihood of achieving desired outcome • Expectancy = belief that actions lead to desired outcomes	• Kiatkawsin & Han (2017) combined this model with Stern's VBN theory (see diagram below the table)	• On its own, theory lacks social context as a variable, (too simple and only focused on factors of self)
Self-efficacy Theory	Bandura (1977)	Educational psychology	• Efficacy expectancy: the belief that one has the skills to carry out a particular action that will lead to a desired outcome • Outcome expectancy: the belief that one's actions will lead to a desired outcome • Perception of self-efficacy impacts motivation and the level persistence in committing to achieving a particular outcome	• Wigfield and Eccles (2002) built on the self-efficacy part to further develop the idea of achievement motivation	
Norm activation model	Schwartz (1977)	Social psychology	• Moral and personal norms dictate pro-social behaviour • This model is used more by researchers who believe pro-envi behaviour is driven by motives of prosocial behaviour ○ Feelings of strong moral obligation to behave with others in mind (research showed strong pro-social norm activation for following behaviours, which supports Hines (1986/87) correlation $r = 0.33$ for moral obligation vs. PEB): ■ Energy conservation ■ Recycling ■ Travel-mode choice ■ Green consumerism	• Inspired Stern's VBN model (which is a combination of NEP and norm activation)	• Han (2014) modified this further to make it a sequential model to test predictability, and included factors of pride, guilt, attitudes and social norm to the original model (based on other research)
Theory of Planned Behaviour and Theory of Reasoned Action	Ajzen & Fishbein (1980, developed upon research from 1975)	Social psychology	• Attitude is a strong driver for behaviour • Uses 'intention' as a go between attitudes and behaviours • Attitude → intention ⇒ behaviour  FIG. 2. Theory of reasoned action (Ajzen & Fishbein, 1980). • This model is used by researchers who believe self-interest is the major driving force for behaviour	• Kaiser et al. (2005): uni student conservation behaviour • Han (2015) merged this model with VBN theory for greater predictive power	• Harding (2020): used this and VBN, but found no change in knowledge and attitudes, though some change in pro-environmental behaviour (Gr. 6 students self-reported behaviour)

Responsible Environmental Behaviour Model	Hungerford & Volk (1990)	Environmental education, green consumerism and marketing	 Figure 3. Environmental Behavior Model: Major and Minor Variables Involved in Environmentally Responsible Behavior.	• more theoretical examination than operationalized theory	•
Theory of Ecological Attitudes: 2-MEV model	Bogner & Wiseman (1999)	Environmental education, educational psychology	 **Figure 2** Our final model and the standardized estimates of the various coefficients, including correlations between specific (error) terms. $\chi^2 = 2.80$, df = 3, $p = .42$.	• Bogner et al. (many works): engage European adolescents in surveys after environmental programmes • Johnson & Manoli (2008): outdoor ed program, Sunship Earth, positively impacts pre-teens towards self-reported pro-envi perspectives • Liu & Chen (2019): modified it for Chinese children envi attitudes and found modified 2-MEV more reliable in predicting pro-envi behaviour than NEP	• Bogner (2018): added another scale aspect to the 2 variable model: added 'Appreciation' to the Preservation and Utilization axes, as appreciation of nature can be for its intrinsic value but also extrinsic 'nature as resource' value
Value-belief-norm (VBN) Theory	Stern (2000) [Stern, 1999; Dietz et al., 1998;	Environmental education and environmental psychology	• VBN significantly accounts for general causes of having pro-environmental attitudes and behaviours; as social values did relate to envi action (study shows) • Behaviour depends on a range of factors, and specific behaviours have specific driving variables, so combining theories may be more effective than a general environmental theory (may be too simplified) • Attitudinal factors impact behaviour greatly when context and personal capability isn't vital	• Kiatkawsin & Han (2017) combined this model with Vroom's expectancy theory (see diagram below the table) for research measuring green-minded tourism (in uni students)	

<table>
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<td>Stern & Dietz, 1994)</td>
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● Behaviours that are challenging to do or have a high barrier to entry (expensive) see personal context or capacity causes playing a more significant role than attitude.
● [Stern, 1999]: incentives & information interact and more powerful to influence behaviour than their sum done separately
● [Gardner & Stern, 1996]: barriers must be removed before action can take place

Table 1. Variables Influencing Environmentally Significant Behaviors

Contextual Factors (constraint and facilitation)
• Available technology
• Embodied environmental impact, e.g., energy efficiency of buildings, vehicles; materials in consumer products
• Legal and regulatory requirements
• Material costs and rewards (payoffs)
• Convenience, e.g., of public transit, recycling
• Social norms and expectations
Personal Capabilities
• Financial resources
• Literacy
• Social status
• Behavior-specific knowledge and skills
Habit and Routine
Attitudinal Factors
• Personal values
• General environmentalist predisposition (abstract norms)
• Behavior-specific (concrete) norms and beliefs
• Nonenvironmental attitudes, e.g., about product attributes
• Perceived costs and benefits of action

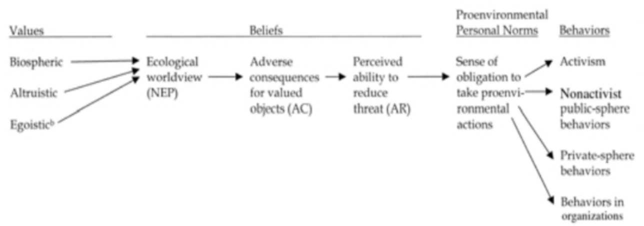

Fig. 1. A schematic representation of variables in the VBN theory of environmentalism[a]
[a] Arrows represent postulated direct effects. Direct effects may also be observed on variables more than one level downstream from a causal variable.
[b] Empirically, measures of egoistic values have been negatively correlated with indicators of environmentalism.
</td>
<td>● Harding(2020) used this and the Theory of Planned Behaviour as a combined model</td>
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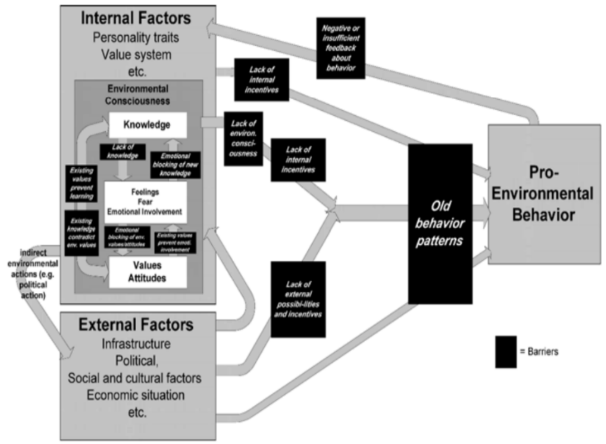
New Environmental Paradigm (scale)	Dunlap and Liere, 1978, 2010	Environmental education and environmental psychology	1. We are approaching the limit of the number of people the earth can support. 2. The balance of nature is very delicate and easily upset. 3. Humans have the right to modify the natural environment to suit their needs. 4. Mankind was created to rule over the rest of nature. 5. When humans interfere with nature it often produces disastrous consequences. 6. Plants and animals exist primarily to be used by humans. 7. To maintain a healthy economy we will have to develop a "steady-state" economy where industrial growth is controlled. 8. Humans must live in harmony with nature in order to survive. 9. The earth is like a spaceship with only limited room and resources. 10. Humans need not adapt to the natural environment because they can remake it to suit their needs. 11. There are limits to growth beyond which our industrialized society cannot expand. 12. Mankind is severely abusing the environment.	● Jackson et al. (2016, 2017): HK students envi attitudes (used the NEP scale) and compared local and international school students (self-reported behaviours)	● Manoli et al. (2019): in a 2-MEV and NEP comparative study of 1400+ 4th & 5th grades in US schools found NEP too unidimensional to be useful, preferred 2-MEV multi-directional use of +PRE+UTL and -PRE-UTL quadrants ● Nisbet et al. (2009): lacks aspects inquiring personal experience in nature and emotional responses about being in nature ● Barr & Gilg highlight that many studies using NEP have shown inconclusiveness about one's values & behaviour; list other authors showing equal skepticism
'Mind the Gap' model	Kollmuss & Agyeman (2002)	Environmental education and environmental psychology	 FIG. 7. Model of pro-environmental behaviour (Kollmuss & Agyeman).	● many papers reference this paper to use aspects of their summarizing of the literature, rather than in reference to their complication model.	● Courtenay-Hall & Rogers (2002): express lots of reservations: ○ direct vs. indirect action: by ranking one over the other (K&A) show bias that direct action has greater impact, but ignores the inequality or socio-economic & political dimensions of those actions and where the responsibilities should lie

Nature Relatedness (scale)	Nisbet et al., 2009	Environmental education and environmental psychology	• Nature Relatedness (NR) includes the appreciation of aesthetic aspects of nature, but also incorporates the understanding of the value of human-nature interconnectedness (that may involve less desirable parts of nature, i.e. scary species like reptiles, etc.)
			• Scales covers affective, cognitive and experiential realms of NR:
			  • NR-Self: feelings about one's connection to nature as part of identity
			  • NR-Perspective: notion of one's impact on and responsibility to nature
			  • NR-Experiences: reflects physical familiarity and need to be in nature
			• Better able to predict self-reported pro-environmental behaviour than Dunlap's NEP; though it was mainly tested on Canadian psych undergrad students (~830) and Canadian executive level adults (~140)
				• NR-6 is a shortened version that has internal consistency as the longer 21 question scale (NR)	• Not many published papers have other researchers using this scale (it's mainly just the co-authors of this original paper) - what does that imply?

Framework of Environmental Behaviour: Environmental concept with situational and psychological variables	Barr, Gilg & Ford (2001, update in 2007 by Barr & Gilg)	Environmental education, Green consumerism and marketing	• Holistic lens of variables that shows quantitative data can be analyzed to consider the inter-relationships between variables • Shows that you need more than awareness or information from campaigns to bring about behaviour • Habitual consumptive behaviours are also a valid way to express environmental aptitude and sensitivity (composting, being a green consumer), and not just when addressing specific envi issues, i.e. beach clean-ups/setting up community gardens, etc. • Based on a study in 3 areas around Devon (random stratified from 1240 participants/households • Used factor analysis to consider empirical links between the variables in the green consumer questionnaire • Further, used stepwise regression analyses to determine the relationship between behaviour and behavioural intention from an explanatory perspective • Analyses showed valid relationships between variables, especially showing intentions highly influenced behaviour for 'purchasing decisions' → which adds strength to Azjen and Fishbein's idea about intentions leading up to behaviour (and not just attitudes and values leading to behaviour) → however, one must note that there still are other variables that have an impact, such as green consumer and moral beliefs, logistics and convenience, and price. ○ Habitual intention vs. habitual behaviour also shows that intention was a primary factor, though again, morals played a 2nd more significant factor	• many papers have referenced their research about environment consumer behaviour	• none that I've come across yet, but this framework has not been used in an educational intervention setting, so this would be quite novel!

Barr and Gilg's (2007) Environmental Behaviour Framework

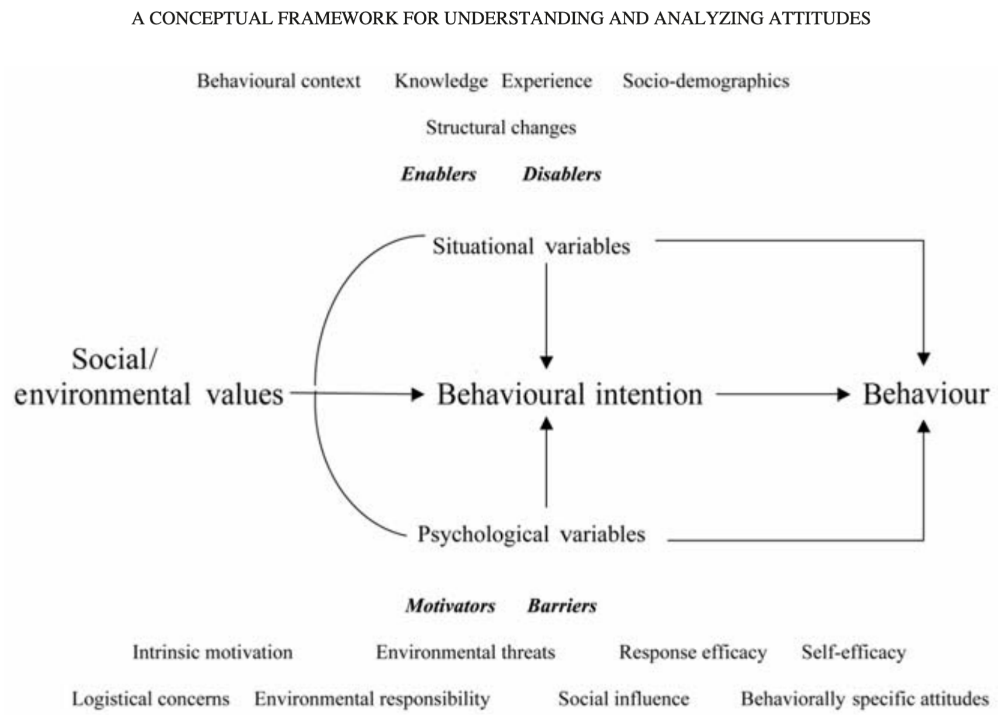
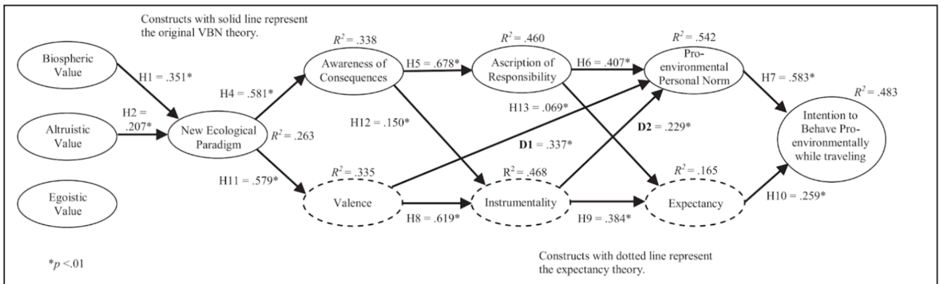


Fig. 2. Detailed conceptual framework.

From Kiatkawsin and Han (2017): combined VBN theory and expectancy theory (operationalized for structural equation modeling analysis)



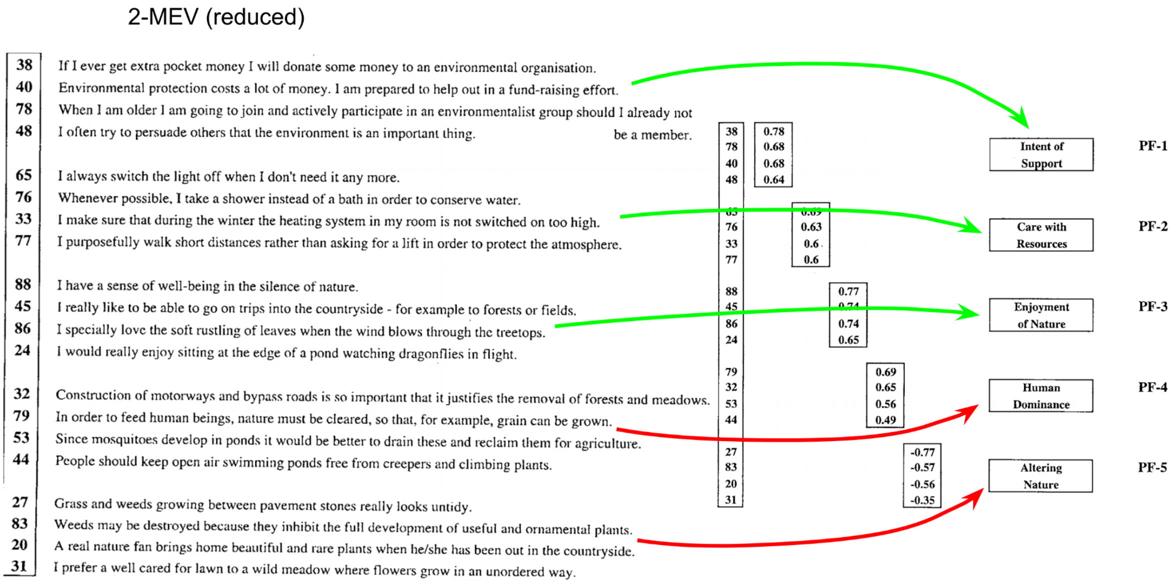
Note 1. Goodness-of-Fit Statistics for the final model: χ^2 = 1228.224, df = 607, p < .001, χ^2/df = 2.140, RMSEA = .046, CFI = .929, IFI = .930, TLI = 922, NFI = .876, PGFI = 762

Fig. 2. Result of the structural equation modeling (Final Model).

APPENDIX B - Developing my environmental values scale

Modifying the 2-MEV scale for my Hong Kong educational context with inspiration from the original 2-MEV scale (Bogner & Wiseman, 1999, 2006), Nature Relatedness scale (Nisbet et al., 2009), Liu and Chen's (2019) modification to the 2-MEV scale, and Olsson et al. (2016).

Bogner and Wiseman (1999) scale:



Bogner and Wiseman (2006) scale:

Item	Preservation
P1	It upsets me to see the countryside taken over by building sites.
P2	I enjoy trips to the countryside.
P3	Humankind will die out if we don't live in tune with nature.
P4	Society will continue to solve even the biggest environmental problems.
P5	Sitting at the edge of a pond watching dragonflies in flight is enjoyable.
P6	I save water by taking a shower instead of a bath.
P7	I always switch the light off when I don't need it.
P8	We must set aside areas to protect endangered species.
P9	It is interesting to know what kinds of creatures live in ponds or rivers.
P10	Dirty industrial smoke from chimneys makes me angry.
	Utilization
U1	Worrying about the environment often holds up development projects.
U2	We need to clear forests in order to grow crops.
U3	Our planet has unlimited resources.
U4	Nature is always able to restore itself.
U5	We must build more roads so people can travel to the countryside.
U6	Only plants and animals of economic importance need to be protected.
U7	Humans have the right to change nature as they see fit.
U8	People worry too much about pollution.
U9	Human beings are more important than other creatures.
U10	We should remove garden weeds to help beautiful flowers grow.

Table S1. Modified 20-item 2-MEV scale (original items

From Liu & Chen (2019)

	Original scale item
Preservation	
P_1	It upsets me to see the countryside taken over by building sites.
P_2	I enjoy trips to the countryside (woods, meadow).
P_3	Humankind will die out if we don't live in tune with nature.
P_4	Society will continue to solve even the biggest environmental problems.
P_5	Sitting at the edge of a pond watching dragonflies in flight is enjoyable.
P_6	I save water by taking a shower instead of a bath (in order to spare water).
P_7	I always switch the light off when I don't need it.
P_8	We must set aside areas to protect endangered species.
P_9	It is interesting to know what kinds of creatures live in ponds or rivers.
P_{10}	Dirty industrial smoke from chimneys makes me angry.
Utilization	
U_1	Worrying about the environment often holds up development projects.
U_2	We need to clear forests in order to grow crops.
U_3	Our planet has unlimited resources (e.g, potable water, wood, coal, or oil).
U_4	Nature is always able to restore itself.
U_5	We must build more roads so people can travel to the countryside.
U_6	Only plants and animals of economic importance need to be protected.
U_7	Humans have the right to change nature as they see fit.
U_8	People worry too much about pollution.
U_9	Human beings are more important than other creatures.
U_{10}	We should remove garden weeds to help beautiful flowers grow.

Promax Rotation on Nature Relatedness (NR) Items

NR-6 in purple

Item	Factor 1	Factor 2	Factor 3
NR-Self			
My connection to nature and the environment is a part of my spirituality	**.87**	–.2	
My relationship to nature is an important part of who I am	**.86**	–.16	.12
I feel very connected to all living things and the earth	**.77**		
I am not separate from nature, but a part of nature	**.46**		
I always think about how my actions affect the environment	**.46**	.19	
I am very aware of environmental issues	**.45**	.16	
I think a lot about the suffering of animals	**.43**	.26	–.18
Even in the middle of the city, I notice nature around me	**.41**		.26
My feelings about nature do not affect how I live my life	**.39**		.21
NR-Perspective			
Humans have the right to use natural resources any way we want		**.52**	
Conservation is unnecessary because nature is strong enough to recover from any human impact	–.15	**.51**	
Animals, birds and plants have fewer rights than humans		**.42**	
Some species are just meant to die out or become extinct		**.28**	
Nothing I do will change problems in other places on the planet	.17	**.26**	
The state of nonhuman species is an indicator of the future for humans	.17	**.17**	
NR-Experience			
The thought of being deep in the woods, away from civilization, is frightening	–.22		**.81**
My ideal vacation spot would be a remote, wilderness area			**.63**
I enjoy being outdoors, even in unpleasant weather			**.62**
I don't often go out in nature			**.59**
I enjoy digging in the earth and getting dirt on my hands	.11		**.44**
I take notice of wildlife wherever I am	.27		**.38**

Table S1. Modified 20-item 2-MEV scale (original items

Blue & Pink Qs from original 2-MEV scale, Orange are Liu & Chen created

	Original scale item
Preservation	
P_1	It upsets me to see the countryside taken over by building sites.
P_2	I enjoy trips to the countryside (woods, meadow).
P_3	Humankind will die out if we don't live in tune with nature.
P_4	Society will continue to solve even the biggest environmental problems.
P_5	Sitting at the edge of a pond watching dragonflies in flight is enjoyable.
P_6	I save water by taking a shower instead of a bath (in order to spare water).
P_7	I always switch the light off when I don't need it.
P_8	We must set aside areas to protect endangered species.
P_9	It is interesting to know what kinds of creatures live in ponds or rivers.
P_{10}	Dirty industrial smoke from chimneys makes me angry.
Utilization	
U_1	Worrying about the environment often holds up development projects.
U_2	We need to clear forests in order to grow crops.
U_3	Our planet has unlimited resources (e.g, potable water, wood, coal, or oil).
U_4	Nature is always able to restore itself.
U_5	We must build more roads so people can travel to the countryside.
U_6	Only plants and animals of economic importance need to be protected.
U_7	Humans have the right to change nature as they see fit.
U_8	People worry too much about pollution.
U_9	Human beings are more important than other creatures.
U_{10}	We should remove garden weeds to help beautiful flowers grow.

2-MEV (reduced)

38	If I ever get extra pocket money I will donate some money to an environmental organisation.
40	Environmental protection costs a lot of money. I am prepared to help out in a fund-raising effort.
78	When I am older I am going to join and actively participate in an environmentalist group should I already not be a member.
48	I often try to persuade others that the environment is an important thing.
65	I always switch the light off when I don't need it any more.
76	Whenever possible, I take a shower instead of a bath in order to conserve water.
33	I make sure that during the winter the heating system in my room is not switched on too high.
77	I purposefully walk short distances rather than asking for a lift in order to protect the atmosphere.
88	I have a sense of well-being in the silence of nature.
45	I really like to be able to go on trips into the countryside - for example to forests or fields.
86	I specially love the soft rustling of leaves when the wind blows through the treetops.
24	I would really enjoy sitting at the edge of a pond watching dragonflies in flight.
32	Construction of motorways and bypass roads is so important that it justifies the removal of forests and meadows.
79	In order to feed human beings, nature must be cleared, so that, for example, grain can be grown.
53	Since mosquitoes develop in ponds it would be better to drain these and reclaim them for agriculture.
44	People should keep open air swimming ponds free from creepers and climbing plants.
27	Grass and weeds growing between pavement stones really looks untidy.
83	Weeds may be destroyed because they inhibit the full development of useful and ornamental plants.
20	A real nature fan brings home beautiful and rare plants when he/she has been out in the countryside.
31	I prefer a well cared for lawn to a wild meadow where flowers grow in an unordered way.

	Questions	2-MEV category
1	I enjoy being in nature (parks, countryside, beaches, gardens, forests, hills).	Enjoy / appreciation
2	Nature must be changed or altered to feed the increasing number of humans on Earth (for example: clear forests for agricultural and animal farms, clear mangroves for fish farms).	alter
3	Conservation is not necessary because nature is strong enough to recover from any human impact.	alter
4	Humankind will suffer/die out if we do not live in harmony with nature.	human
5	Knowing how to properly sort waste into paper, metal, plastic, glass and food waste is a trait of an environmentally-minded person.	intent
6	Human beings are more important than other creatures or biological life.	human
7	One should avoid buying from companies that have a negative impact on the environment (for example: avoid foods with palm oil; avoid cosmetics with microplastics).	intent
8	It is interesting to know which animals and plants exist in my community and the world.	Enjoy / appreciation
9	Only plants and animals of economic importance and value need to be protected.	human
10	Cleaning up the environment and protecting endangered plant & animal species must be done, even if this costs government money that could have been spent on supporting other important issues.	care
11	Refusing to use single-use plastic items (straws, take-away plastic cutlery, plastic grocery bags) is an effective way to take action about consumer related environmental issues.	care
12	I prefer a well-cared for garden than a wild forest where plants grow in an unordered way.	alter
13	My connection to nature is an important part of who I am.	enjoy
14	Every individual must make contributions towards positively impacting the environment.	care
15	Humans have the right to use natural resources any way we want.	human
16	In order to access and enjoy nature, there needs to be a balance between infrastructure and construction, and environmental protection.	alter

Smriti Safaya
21 Feb 2020

orange questions from 2-MEV/modified 2-MEV scale (Bogner and Wiseman), with localized adaptation

Smriti Safaya
21 Feb 2020

light pink = Nature Relatedness scale (Nisbet et al., 2009)

Smriti Safaya
21 Feb 2020

Green Qs are inspired from Swedish study of students' sustainability attitudes (Olsson et al., 2016): http://www.intra.kau.se/dokument/upload/C10B9B9407a521999AyJFE893282/Survey%20instrument%209th%20grade.pdf?-session=rs:C10B9B9407a52196DCKhFF628D47Grade%20twelve:http://www.intra.kau.se/dokument/upload/C10B9B9407f0220FC9Njh15BB799/Survey%20instrument%2012th%20grade%20webversion.pdf

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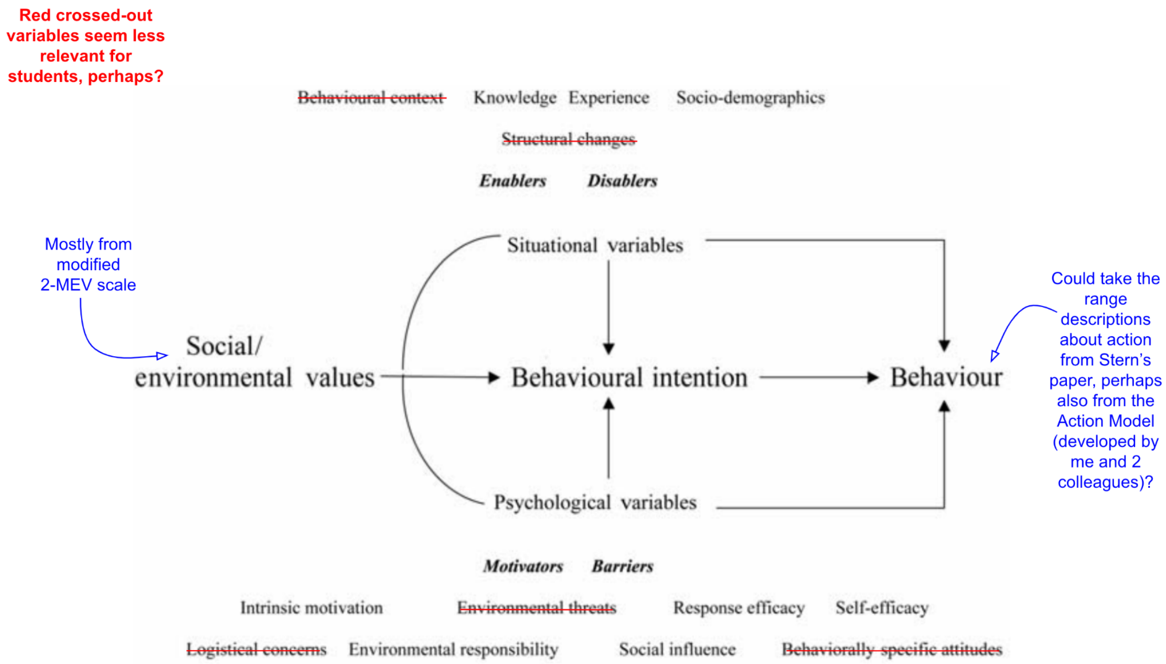
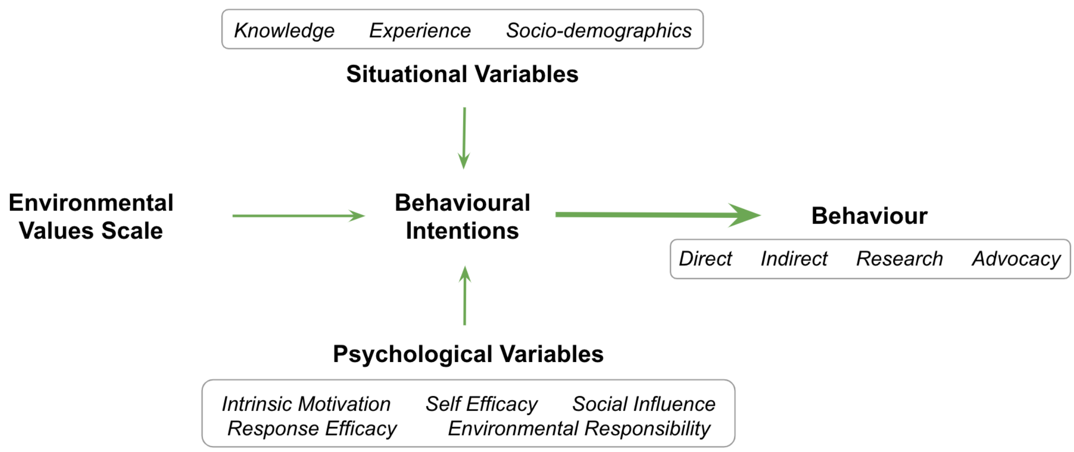
APPENDIX C - Extracts of how I developed my measurements for situational, psychological and behaviour variables



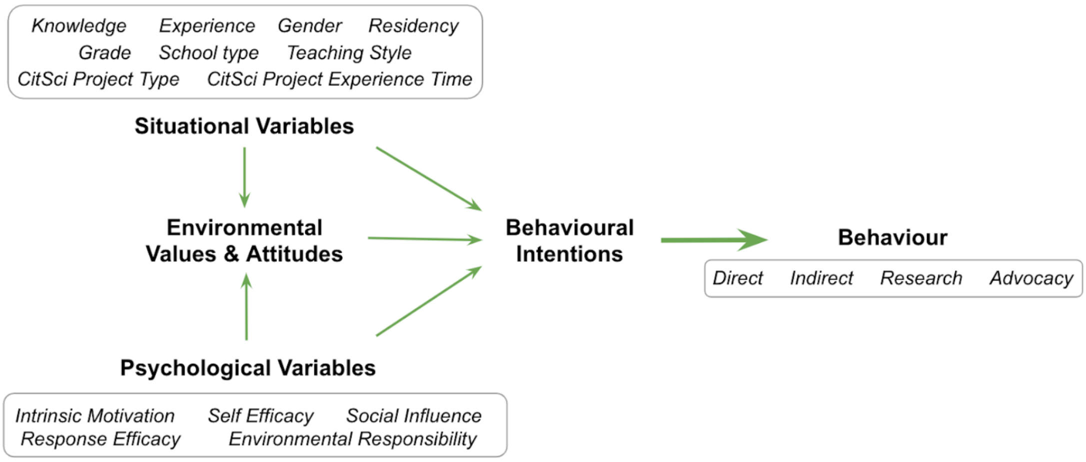
Conceptual model for my research: **Ecological Attitudes Scale*** & **Environmental Behaviour Framework****



Ecological Attitudes Scale created by Bogner and Wiseman (1999)
*** Environmental Behaviour Framework created by Barr and Gilg (updated in 2007)*

My conceptual model (as of Aug 2020)

Conceptual model for my research: modified from **Ecological Attitudes Scale*** & **Environmental Behaviour Framework****



*Ecological Attitudes Scale created by Bogner and Wiseman (1999)
** Environmental Behaviour Framework created by Barr and Gilg (updated in 2007)

Behaviour variable's potential question items, inspired from Barr and Gilg (2007), Bogner and Wiseman, 1999, 2006 (orange highlight), Olsson et al., 2016 (green highlight), Nisbet et al., 2009 (lavender highlight) and my own based on local Hong Kong and school-based experiences (yellow highlight)

	Questions
1	I seek opportunities to engage with nature (visit urban parks & gardens, be active in Country/Marine parks, observe biodiversity in natural habitats, visit environmental centres).
2	I use my own initiative to find information and news regarding Hong Kong and/or global environmental issues.
3	Environmental NGOs are groups that I support by donating some money or my time & effort (volunteering, signing petitions, etc.)
4	Using single-use plastics (like straws, cutlery, etc.) or packaging (plastic bags, styrofoam food container, etc.) is something I do.
5	I think about how my buying habits impact the environment or biodiversity before I make purchases.
6	During this school year, I have chosen to participate in environmental events (for example: nature-based field trips, environmental club events, beach clean-ups)
7	I talk to my friends and family about doing actions that help the environment (for example: change buying/eating habits, use public transport, reusing & recycling, etc.)
8	When I notice garbage in nature, I pick it up and dispose of it properly.
9	If I'm the last to leave a room, I turn off the electrical appliances not in use (for example: lights, aircons, fans, etc.).
10	I use my own reusable cutlery/straws/take-away container when I'm eating outside of my home to avoid making waste.
11	Solutions to Hong Kong and/or global environmental challenges are topics I independently research.
12	I share information about environmental issues on social media

APPENDIX D – Pre-survey and Post-Survey Questions

VARIABLE TYPE
categorical / nominal
ordinal
numerical
mixed

Student pre-survey and post-survey questions

Variable	Sub-category	Q #s	Question	Scale
Environmental Values	Enjoy	1	I enjoy being in nature (parks, countryside, beaches, gardens, forests, hills).	5-pt Likert (Strongly agree, agree, neutral, disagree, strongly disagree)
		2	It is interesting to know which animals and plants exist in my community and the world.	
		3	My connection to nature is an important part of who I am.	
	Care	4	Cleaning up the environment and protecting endangered plant & animal species must be done, even if this costs money that could have been spent on supporting other important issues.	
		5	Refusing to use single-use plastic items (straws, take-away plastic cutlery, plastic grocery bags) is a useful way to take action about reducing waste.	
	Alter	6	Nature must be changed or altered to feed the increasing number of humans on Earth (for example: clear forests for agricultural and animal farms, clear mangroves for fish farms).	
		7	I prefer a well-cared for garden than a wild forest where plants grow in an unordered way.	
	Human	8	Human beings are more important than other creatures or biological life.	
		9	Only plants and animals of economic importance and value need to be protected.	
		10	Humans have the right to use natural resources any way we want.	

Variable	Sub-category	Q #s	Question	Scale (out of 6 marks)
Knowledge (Situational)	Local	11	Name any 3 environmental NGOs working in Hong Kong.	Short answer (1 mark if they accurately name 3, 0 marks if they name 2 or fewer)
		12	What is the name of the government department responsible for environmental issues in Hong Kong? *Choices: Green Power Department, Environmental and Biodiversity Department, Environmental Protection Department, Environmental Policy Department, I do not know*	Multiple Choice
		13	Which of these kinds of protected areas do NOT exist in Hong Kong? *Choices: National Park, Marine Protected Area, Country Park, Marine Reserve, I do not know*	Multiple Choice
		14	Which categories exist for the combination recycling bins commonly found around Hong Kong? *Choice of Yes/No for each of the following types: metal, electrical equipment, paper, cardboard, food waste, plastic, clothes, glass*	Yes / No for each type
	Global	15	What main issue has youth activist Greta Thunberg been talking about for the past few years? Choice: Overpopulation, Biodiversity Conservation, Pollution, Climate Change, Illegal Wildlife Trade, I do not know	Multiple Choice
		16	The name of the 2015 global initiative by the United Nations to transform our world for the better, is known as: *Choices: Millenium Development Goals, ZeroPoverty Goal, Sustainable Development Goals, Circular Economy, I do not know*	Multiple Choice

Variable	Sub-category	Q #s	Question	Scale (out of 10)
Experience (Situational)	Personal	17	In a typical school year (before Covid-19), how often have you experienced the following activities? *Choices: school-organized field trip in nature, school-organized trip to environmental lecture/centre/exhibition/museum, personal trip in nature, personal trip to an environmental lecture/centre/exhibition/museum*	5-pt frequency scale (Very frequently, Often, Sometimes, Rarely, Never)
	Household	18	How often have you seen your family do the following activities? *Choices: waste separation at home, sort clothes for second-hand donations, bring your own bag for shopping, consider buying the highest-rated energy-efficient electronics option instead of the less energy-efficient alternative, buy bottled water for home consumption; discuss environmental issues*	

Variable	Sub-category	-	Question	Scale
Socio-demographics (Situational)	All of these questions were only on the pre-survey, with the exception of first and last name, and school email	-	First & Last Name	Short Answer
			Gender	F/M/Other/Prefer Not to Say
		-	Grade / Year	Multiple Choice (Gr. 6/Year 7 to Gr. 12/Year 13)
		-	School Name	Short Answer
		-	School Email	Short Answer
		-	Number of years living in Hong Kong *Choices: <3 years, 4-6 years, 7-9 years, 10-12 years, 13-15 years, 16-18 years*	Multiple Choice
		-	Prior experience with citizen science	Multiple Choice
		-	Define the term 'citizen science'	Short Answer

Variable	Sub-category	Q #s	Question	Scale (out of 10)
Response Efficacy (Psychological)	Conceptual	19	To what extent do you agree with Margaret Mead's quote, "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has"?	5-pt Likert (Strongly agree, agree, neutral, disagree, strongly disagree)
	Individual	20	My actions can impact change at a local level, which still makes a difference to the larger environmental issue.	

Variable	Sub-category	Q #s	Question	Scale (out of 25 each)
Self-efficacy (Psychological)	Personal perception (importance)	21	The folllowing skills are vital in being able to act on an environmental issue one cares about: *Choices: research and inqury skills, planning and organization, teamwork and collaboration, presentation and communication*	5-pt Likert (Strongly agree, agree, neutral, disagree, strongly disagree)
	Actual experience (development) - only in post-survey	22	I have been developing the following skills from my recent citizen science experience: *Choices: research and inqury skills, critical thinking and analysis, planning and organization, teamwork and collaboration, presentation and communication*	
	Personal perception (confidence)	23	I currently have confidence in using the following skills to take action about environmental issues: *Choices: research and inqury skills, critical thinking and analysis, planning and organization, teamwork and collaboration, presentation and communication*	

Variable	Sub-category	Q #s	Question	Scale (out of 10)
Intrinsic motivation (Psychological)	personal perception	24	I derive personal satisfaction from being a responsible citizen.	5-pt Likert (Strongly agree, agree, neutral, disagree, strongly disagree)
		25	I gain personal satisfaction from doing things that will matter in the long-term for the environment	

Variable	Sub-category	Q #s	Question	Scale (out of 10)
Social Influence (Psychological)	personal community	26	Observing people harming the environment, makes me more motivated to take my own positive action.	5-pt Likert (Strongly agree, agree, neutral, disagree, strongly disagree)
	personal community	27	Seeing people I know (family, friends, teachers, etc.) doing things for the environment has a positive influence on my behaviour.	
	social media	28	Stories about positive environmental behaviour on social media motivate me to do more for the environment.	

Variable	Sub-category/citizen action form (personally responsible (p.r.), participatory (p), justice-oriented (j.o.)	Q #s	Question	Scale (out of 25)
Behavioural Intention	all 4; all 3	29	I would be willing to sacrifice some of my time to take positive actions for the environment.	5-pt Likert Likelihood scale (Highly likely, somewhat likely, unsure, somewhat unlikely, highly unlikely)
	indirect; p.r.	30	Spending a little more money on environmentally-friendly goods and services is something I would do.	
	research; j.o.	31	If I observe waste around my neighborhood, I would want to know where it comes from and what can be done about it.	
	direct; p	32	I would decide against buying a take-away food or drink item, if I forgot to bring my own container.	
	advocacy; p	33	When given the chance to share my concern about the environment with my community, I would take it.	

Variable	Sub-category/citizen action form (personally responsible (p.r.), participatory (p), justice-oriented (j.o.)	Q #s	Question	Scale (out of 50)
Behaviour	direct; p.r.	34	I engage with nature by visiting urban parks, gardens and/or visiting environmental centres.	5-pt frequency scale (Very frequently, Often, Sometimes, Rarely, Never)
	research; p & j.o.	35	I use my own initiative to find information and news regarding Hong Kong and/or global environmental issues.	
	indirect; p.r.	36	Eating meat and/or seafood is part of my diet.	
	advocacy; p	37	I talk to my friends and family about doing actions that help the environment (for example: change buying/eating habits, use public transport, etc.)	
	indirect; p.r.	38	I think about how my buying habits impact the environment or biodiversity before I make any purchase.	
	direct; p.r.	39	When a school-based environmental group organizes events that directly impact the environment positively (for example: beach clean-ups), I participate.	
	direct; p.r.	40	I explore the Hong Kong Country and/or Marine parks to enjoy time in nature.	
	indirect; j.o	41	Upon analyzing the complex aspects about an environmental issue, I take action with people to work on the root causes.	
	research; p & j.o.	42	Solutions to Hong Kong and/or global environmental challenges are topics I independently research.	
	advocacy; p.	43	Raising awareness about environmental issues via petitions, forums and talks, is something I take the lead in organizing.	

APPENDIX E - Interview Questions and Interactive Google Slides Workspace

This chart is to be read vertically, from top to bottom. The arrows are for question order clarity after choices are presented.

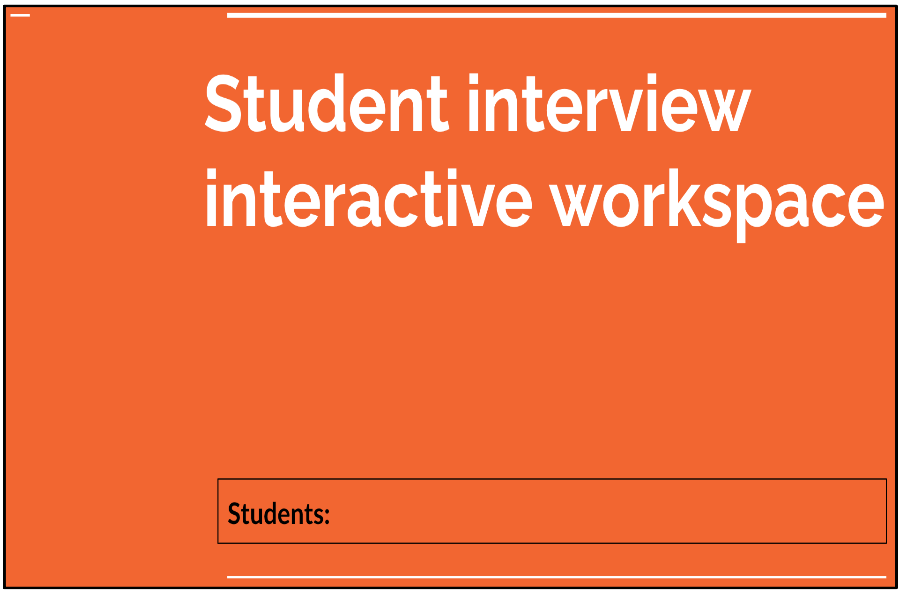
Student Interview Questions Flow Chart

Themes			
Environmental Education	**1**	**Environmental education has been gaining more attention in schools in the last few years.**	
	1a	What do you think the goals of environmental education should be?	
	1b	At (school name), in which subjects, clubs or activities do you experience environmental education?	
	1c	What kind of impact do those experiences have on how you think about and act towards the environment?	
	1d	What are some examples of how students take action for environmental issues at this school?	

Citizen Science Project Experience	**2**	**Let's talk about your recent citizen science experience on (project name).**	
	2a	What did you learn in the topic of _____ (amend based on the project theme) during that citizen science project?	
	2b	How did doing the citizen science project develop things like your: a) research skills? b) planning skills? c) teamwork skills? d) communication skills?	
	2c	Do you think your feelings (values and attitudes) towards the environment have changed as a result of your citizen science experience? Go to slide 4 and use an adjustable arror to represent the scale and direction of change, or if no change, use a dot to show where on the preservation vs. utilisation graph you would place yourself.	
		*if **yes***	*if **no***
	2d	How would you describe they have changed?	Why do you think they have not (really) changed?
		*if **positive** changes* *if **negative** changes*	
	2e	How did your citizen science experience (directly) influence these ideas/feelings/changes?	
	2f	How has your citizen science experience been helpful for learning about the environment or environmental issues? (even could ask, did they go back and check their iNat observations to learn about what specific species they saw?)	
	2g	What would have made your citizen science experience better for learning about the environment or environmental issues?	

Behavioural Change and Action	**3**	**Many things influence how we decide to take action about something. We will explore these ideas in this final part of the interview.**
	3a	Has your citizen science experience influenced you to take any action towards the environment, and if so, how? Feel free to give specific examples of what actions you take.
	3b	In general, what influences you to take actions that are positive towards the environment? *After some initial responses, prompt them to go to the interactive Google Workspace, slide 5.* Which of these variables that influence you to take action are more influenctial and less influential (sort into 2 groups), and justify the decisions.
	3c	Go to slide 6 of your workspace. There are 4 types of actions that peple typically take: direct, indirect, research & advocacy. Have a read through the description of each type and consider the actions you take or have taken, and decide which category it would fit under. Do this for about 1 minute. Out of all the action you take, what proportion of those actions are of the 4 various types of action? Represent that amount as a percentage, and write it in the space below the description, where the orange-coloured question is. Write '0%' if that action type doesn't apply to your actions. If you feel that you don't take any action, then write your thoughts
	3d	Based on your pie charts/ %s, which types of action are most frequently done and why do you think that is the case?
	3e	In your opinion, who is responsible to provide opportunities to act in pro-environmental ways? *(if need be, I can provide prompts of stakeholders like: the individual, industry, government, NGOs, etc.)*
		Prompt them to go to slide after their individual 'Action Type' activity slide.
	3f	Sometimes despite having the energy and ideas to do something about an issue that you care about, you might encounter some obstacles. What are some types of obstacles you encounter when you want to take action?
		On a slide, there are 3 columns with the headings of Personal, Society and System, with some description under each heading to explain these categories.
	3g	On the next slide of your workspace, think about some (pro-environmental) actions you have taken or are taking, and what are the difficulties / obstacles you experience. *Give students 1-2 minutes to do this, then share what you see across them all by sharing your screen.* Possible probing Q: Why do you think certain types of barriers have been more commonly identified by this group?
	3h	*On the final slide, ask students to discuss and unanimously rank the top 2 and bottom 2 effective actions.* Here are different examples of action that a person could take. Please rank them in order of most to least effective. Justify your decision for the top 2 and bottom 2 action examples.
	3i	Before we finish, are there any final thoughts you would like to share about anything we've discussed today?

Student Interactive Google Slides Workspace

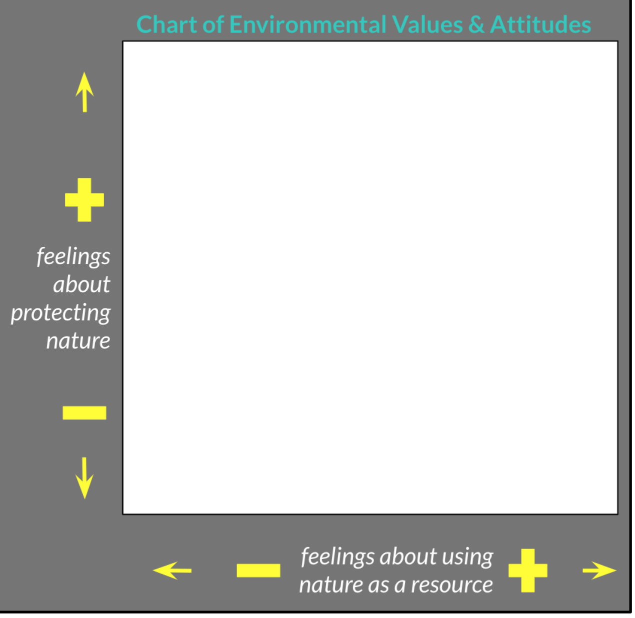


The following slides are a space for you to share your views about specific questions that involve some sorting, writing and ranking.

Values & attitudes

How do you think your values & attitudes might have changed after having your citizen science experience?

Edit your coloured arrow for direction and size to represent your perception of change, and place it on the chart on this slide. If no change, then place your coloured dot where you think you are on the chart



WHAT INFLUENCES YOU TO TAKE ACTION?	*Drag the yellow text boxes into either 'MORE' or 'LESS' influential columns.*
MORE influential	**LESS influential**

Your own personal motivation

The influence of others

Knowledge about environmental issues

Feeling your action makes a difference about the environmental issue

Having skills to take action about the environmental issue

Experience taking some form of action for the environment

Personal values & attitudes about the environment

TYPES OF ACTION FOR name

What proportion (%) of your action fits into these categories?

Add the % in each of the four text boxes after the orange-coloured question prompt. The total of all the percentages should equal 100%.

Direct	Indirect
Action that directly affects the people and/or nature one wants to positively impact. *e.g. beach clean-up, volunteering at an elderly home*	Action that benefits the people and/or nature without directing being in contact with it. *e.g. fundraising, collecting goods for a food drive*
What % of your action is **direct**?	What % of your action is **indirect**?

Research	Advocacy
Action that seeks information on an issue in order to learn about its causes and consequences, and consider what to do about it. *e.g. conducting a community survey*	Action that involves raising awareness about an issue. *e.g. creating a poster campaign or online petition*
What % of your action is **research**?	What % of your action is **advocacy**?

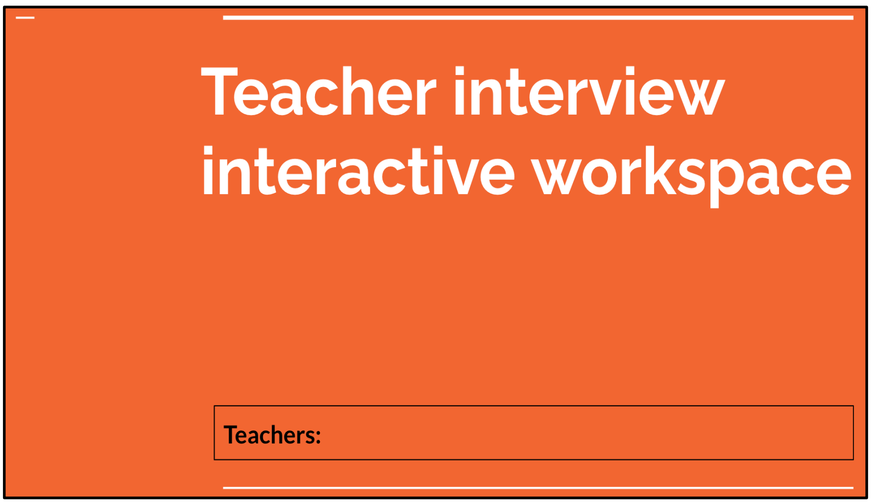
Thank you

for sharing your thoughts about your experience with citizen science!

Teacher Interview Questions Flow Chart

Themes		
Environmental Education	**1**	**Environmental education has been gaining more attention in schools in the last few years.**
	1a	In your opinion, what are the goals of environmental education?
	1b	At *(name of school)*, how are students exposed to environmental education (e.g. classes, extracurricular activities, etc.)?
	1c	What is your impression of the impacts these learning engagements have on students?
Behavioural Change and Action	2a	How do students show their concern for the environment; what kinds of actions do they take? Feel free to mention some specific examples.
	2b	***On the digital workspace:*** What barriers do you think students face in trying to take pro-environmental action?
	2c	What needs to happen (in education) to support a shift towards more pro-environmental student behaviour?
	2d	Some students show little interest in environmental issues, while others exhibit great concern. How do you engage with the range of student values and attitudes towards the environment?
	2e	***On the digital workspace:*** Here are a set of cards with different examples of action that students that I've worked with have undertaken. Please rank them in order of most to least impactful/effective. Justify your decision for the top 2 and bottom 2 action examples.
Citizen Science Project Experience	**3**	**Let's talk about the recent (project name) citizen science experience.**
	3a	What were the objectives of this citizen science project for the students?
	3b	In which ways did the experience meet or not meet your objectives and why?
	3c	How do you feel this experience with citizen science impacts your students': (a) values and attitudes towards the environment? (b) knowledge about this particular environmental issue? (c) motivations for pro-environmental behaviour?
	3d	What motivated you to incorporate citizen science in your teaching?
	3e	How has your experience with citizen science impacted: (a) your own values and attitudes towards the environment? (b) your own learning about the issue? (c) your ideas for teaching about this issue?
		*if **positive** changes* / *if **negative** changes*
	3f	How did the citizen science experience (directly) influence these ideas/feelings/changes?
	3g	Before we finish, are there any final thoughts you would like to share about what we've discussed today?

Teacher Interactive Google Slides Workspace



Barriers to taking action

Personal time, knowledge, motivation, uncertainty about impact and if you feel things are in your control, etc.	**Society** other people's perspectives, access to a support network of like-minded groups, etc.	**System** commercial, industrial or political infrastructures that make it challenging to take action, etc.
•	•	•

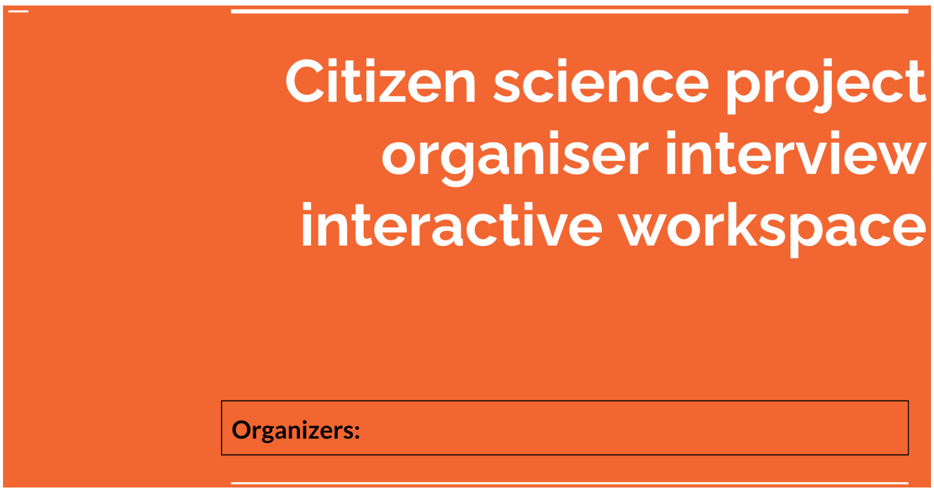
Out of this list of action examples, rank the 2 MOST important/effective (#1, #2) & the 2 LEAST important / effective (#8, #9); writing the number in the 'RANK' column

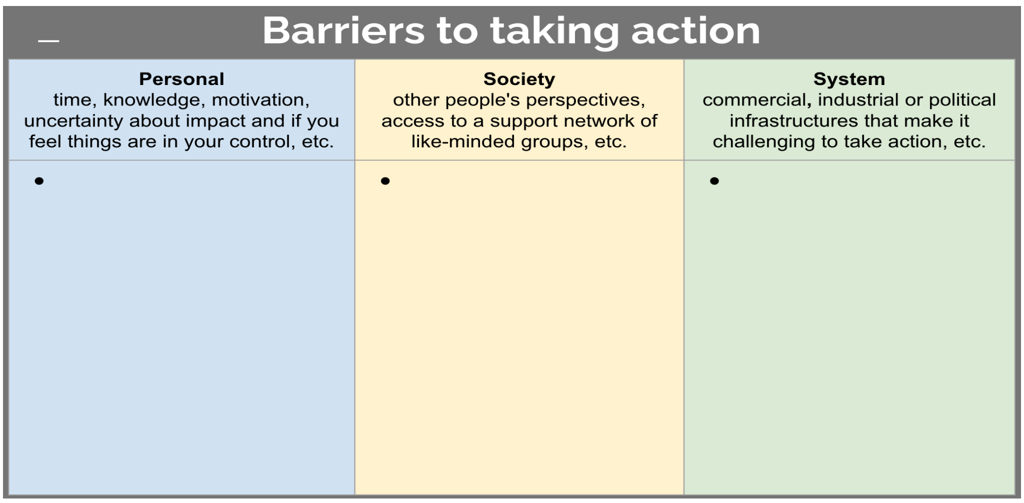
RANK	ACTION
	Organizing a food drive within the school community
	Joining a beach clean-up
	Lobbying corporation through awareness and letter-writing campaigns
	Running a workshop on urban organic farming
	Submitting a petition to the government
	Discussing with local district councillors about a community issue
	Hosting a photography exhibition highlighting local plastic pollution
	Sorting household waste for recycling
	Donating money for a charity fundraiser

CitSci Organizer/Creator Interview Questions Flow Chart

Themes		
Citizen Science Project Experience	**1**	**I would like to start by asking you about the (project name) citizen science project.**
	1a	What motivated you to create / organize / help conduct this citizen science project?
	1b	What are the objectives of this project for the students?
	1c	What are the objectives of this project for the teachers?
	1d	In which ways did the experience meet or not meet your objectives and why?
	1e	How do you think this experience and approach has impacted the way teachers teach?
	1f	When students participate in citizen science, how do you think it impacts their: (a) values and attitudes towards the environment? (b) knowledge about this particular environmental issue? (c) motivation for pro-environmental behaviour?
	1g	How is doing citizen science different from other ways that students typically engage with environmental issues?
Behavioural Change and Action	**2**	**I would like to explore your thoughts about student values, attitudes and action.**
	2a	How do you engage with the range of student values and attitudes towards the environment?
	2b	In general, what factors do you think encourage students to carry out pro-environmental behaviour?
	2c	What barriers do you think students face in trying to take pro-environmental action? (On digital interactive workspace)
	2d	What needs to happen (in education or otherwise) to support a shift towards more pro-environmental student behaviour?
	2e	*On the final slide, ask students to discuss and unanimously rank the top 2 and bottom 2 effective actions.* Here are different examples of action that a student could take. Please rank the two most and two least effective. Justify your decision for the top 2 and bottom 2 action examples.
	2f	Before we finish, are there any final thoughts you would like to share about what we've discussed today?

Citizen Science Organiser Interactive Google Slides Workspace





Out of this list of action examples, rank the 2 MOST important/effective (#1, #2) & the 2 LEAST important / effective (#8, #9); writing the number in the 'RANK' column

RANK	ACTION
	Organizing a food drive within the school community
	Joining a beach clean-up
	Lobbying corporation through awareness and letter-writing campaigns
	Running a workshop on urban organic farming
	Submitting a petition to the government
	Discussing with local district councillors about a community issue
	Hosting a photography exhibition highlighting local plastic pollution
	Sorting household waste for recycling
	Donating money for a charity fundraiser

APPENDIX F - Participant Quote Tracker Summary

Number of quotes used per participant across certain chapters

Student Interviewee	School Type	Citizen Science Project Type	School Level	Gender	Chapter 5	Chapter 6	Chapter 7	Chapter 8
1	IS	C	OS	F		1	1	
2	IS	C	OS	M		2		
3	IS	C	OS	M		4	1	
4	IS	C	OS	F	1	1	1	
5	IS	C	OS	M	n/a	n/a	n/a	n/a
6	IS	C	OS	F				
7	IS	C	OS	F				
8	IS	C	OS	F				
9	IS	C	OS	M			1	
10	IS	C	OS	F		1		
11	IS	C	OS	M	1	2	1	
12	IS	C	OS	M		3	2	
13	IS	C	OS	F		1	1	
14	IS	C	OS	M				
15	IS	C	OS	M				
16	IS	C	OS	F		2	3	
17	IS	C	OS	M				
18	IS	C	OS	M	1	1	2	
19	IS	C	YS	F				
20	IS	C	YS	F	2	5	2	
21	IS	C	YS	M		1	1	
22	IS	C	YS	F	1			
23	IS	C	YS	F			1	
24	IS	C	YS	M			1	
25	IS	C	YS	F		2	1	
26	IS	C	YS	F		1		
27	IS	C	YS	F	1	2	1	
28	LS	C	YS	M		3		
29	LS	C	YS	M		5	1	
30	LS	C	YS	M	1		3	
31	LS	C	YS	M	1		3	
32	LS	C	YS	M		2	1	
33	LS	C	YS	M		1	1	
34	IS	C	YS	F		3	2	
35	IS	Co	OS	M	1	4	5	
36	IS	Co	OS	F		1	1	
37	IS	C	YS	M				
38	IS	C	YS	M		1	4	
39	IS	C	YS	M			1	
40	LS	Co	OS	M			3	
41	LS	Co	OS	M	2	2	2	
42	LS	Co	OS	M		1		
43	LS	Co	OS	M				
44	LS	Co	OS	M				
45	LS	Co	OS	M	2	3	1	
46	LS	Co	OS	M	1	2	4	

<table>
<tr><th>Teacher Interviewee</th><th>School Type</th><th>Citizen Science Project Type</th><th>Teaching Subject Specialty</th><th>Chapter 5</th><th>Chapter 6</th><th>Chapter 7</th><th>Chapter 8</th></tr>
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<tr><td>2</td><td>IS</td><td>C</td><td>Sci</td><td>1</td><td></td><td></td></tr>
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