Earth science field trips in the age of Covid-19: A case study of the SOSC223 virtual field trip

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Louisa Hall

Undergraduate earth science education emphasises the role of field trips in student learning and development. Thus, when the Covid-19 pandemic caused teaching to shift online, many educators developed replacement virtual field trips (VFTs) to deliver the field components of their courses. Such was the case with SOSC223, a second-year geomorphology course at Lincoln University, where the 2021 Covid-19 lockdown saw us replace the scheduled field trips with a VFT to the same locations. In this thesis, I investigate instructor and student experiences developing and learning from the SOSC223 VFT in order to evaluate what may have been lost or gained through the rapid shift from a traditional field trip (TFT) to virtual. I conducted semi-structured interviews with students and staff involved with the VFT and analysed the interview data for themes relating to 1) student and instructors' perceptions of the VFT, 2) the strengths and weaknesses of the trip, and 3) how the VFT compared to a TFT.

Thematic analysis of participants' interview transcripts revealed different overall attitudes between the students and instructors. Instructors' reflections heavily featured the limitations and frustrations of developing the trip during lockdown. They felt the VFT was an adequate resource given the circumstance yet nevertheless saw potential benefits to VFTs as a whole. Students were apprehensive at the outset of the VFT but appreciated having the computerised replacement to the TFTs. Although most would have preferred attending a TFT, they felt the VFT benefitted their learning given the circumstances. The weaknesses of the VFT included its lack of easy interpersonal interaction, its reliance on technology like fast computers and stable internet, and the resourcing requirements to integrate multimedia and scaffold the content of the trip. Despite these challenges, the flexibility and repeatability

of the VFT benefitted all participants, and the trip demonstrated clear potential for well-designed interactive multimedia to facilitate students' visual connection to place and ability to visualise complex processes. The SOSC223 VFT differed from TFTs in the logistical constraints and affordances of each and how the mode of delivery impacted students' social and physical immersion within the learning experience.

Through conducting this research, it became clear that VFTs can add value to course design when thoroughly resourced and thoughtfully integrated. Whether they are used to augment or replace TFTs or incorporated into a course as standalone activities, VFTs should be designed in a way that builds on their flexibility and repeatability, minimises the impact of their lack of sociality, and builds visual connection through well-resourced, well-integrated multimedia.

Keywords: VFT, virtual field trip, field trip education, earth science, geomorphology, Qualitative case study, Canterbury Plains, Kaitōrete Spit, Rakaia River, StoryMaps, Covid-19 teaching

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Chapter 1

Introduction

1.1 Context – COVID-19 in Aotearoa New Zealand

In early 2020 the novel coronavirus SARS-CoV-2 began spreading throughout the world, kicking off the COVID-19 pandemic. Before the development of effective vaccines and antiviral treatments, many countries implemented policies to contain the spread of the virus, including measures like social distancing, mask wearing, quarantines, travel and border restrictions, and lockdowns. Aotearoa New Zealand initially adopted a 4-tier risk management system, with the goal to eliminate the virus domestically until effective vaccines and treatments were developed and available. This management system was in place from March 2020 through October 2021, at which point it shifted from elimination to the "traffic light" risk mitigation system (Unite against COVID-19, 2022).

Alert levels 3 and 4 involved partial to full lockdowns. Alert level 4 Lockdown was used with uncontained COVID transmission and widespread outbreaks. Under level 4, people were to stay at home in their household "bubbles." Travel was restricted to necessities which included grocery shopping, medical care, commuting for essential workers, and local recreation like neighbourhood walks. No gatherings were allowed, all but essential businesses and facilities were closed, so education went online. Alert level 3 Restrict was used when there was medium risk of community transmission with active but managed clusters. This involved a less-strict lockdown, with bubbles extended to include close family/whānau in need of support. Businesses could open if they could trade in a contactless way, though people were expected to work and learn from home if possible. While some schools opened face-to-face under level 3, tertiary instruction was still delivered remotely.

New Zealand had two country-wide lockdowns, at the start of the pandemic in March 2020, which succeeded in eliminating COVID-19 in New Zealand, and again in August 2021, when the more transmissible Delta variant escaped border isolation. The second lockdown hit right in the middle of the first term of semester 2 at Lincoln University, and all teaching was online from August 18 through September 8, 2021 (B.A. McKenzie, personal communication,

August 17, 2021 and September 6, 2021). Two field trips in SOSC223 could not take place as scheduled and we faced a choice: Cancel the trips or deliver them remotely.

The course examiner and I, as the laboratory tutor for SOSC223, chose to try to recreate the two field trips as a single virtual field trip (VFT) using Esri StoryMaps. This project grew from our experiences that semester – I was fortunate to be able to interview instructors and students in the course within a qualitative case study to investigate our attitudes, experiences and evaluate what was lost and gained by pivoting to a VFT during lockdown.

1.2 Project rationale

Field trips are a well-established teaching tool in the natural sciences and are held in high regard by instructors and students alike (Jones & Washko, 2021; Kent, 1997; Petcovic et al., 2014). They are valued for developing students' physical professional skills such as learning field-specific sampling technique, how to make observations, and learning how to take field notes, sketches, or maps (Andrews et al., 2003). Field trips have demonstrated benefits in cognition and understanding that lead to deeper learning and developing collaborative skills (Kern & Carpenter, 1986; Stokes & Boyle, 2009), and can foster metacognitive gains in self-reflection of learning and increased self-efficacy in the field (Mogk & Goodwin, 2012; Petcovic et al., 2014). Field trips are also valued for their benefits to the *affective domain*, covering feelings, attitudes, and motivations, which include enjoyment of being in the field and increased sense of belonging within a discipline (Boyle et al., 2007; Petcovic et al., 2014).

Due to COVID-19, many universities went to fully remote teaching during parts of 2020 and 2021, and while lectures could be recorded and posted online or delivered over video conferencing software like MS Teams or Zoom, shifting to remotely delivered laboratories and field trips was more difficult. Studies on the impacts of lockdowns and Emergency Remote Teaching (ERT) on student engagement and learning identify challenges including students maintaining self-motivation, missing peer and instructor presence, and losing these hands-on experiences (Means & Neisler, 2020).

One way instructors tried to conserve the learning and engagement facilitated by field trips was to develop virtual field trips (VFTs) to replace the experiences students would otherwise lose (e.g., Arthurs, 2021; Peace et al., 2021; Schulze et al., 2021). VFTs are digital experiences that attempt to capture the physical environment of a location without being there. They

often incorporate a mix of photography, maps and satellite imagery, relevant GIS data, and explanatory text and video (Cliffe, 2017). When Aotearoa New Zealand went into a nation-wide lockdown to minimize the spread of Delta, two field trips in the course SOSC223 *Physical landscapes: formation and function* were unable to run as scheduled. Instead of cancelling them, we ran a VFT to the same locations.

The SOSC223 examiner and I developed the Canterbury Plains VFT during the August lockdown to attempt to replace the field trips to Te Waihora/Kaitōrete Spit on the Canterbury coast and the Rakaia River on the Canterbury Plains. These trips aimed to teach students about the geomorphic history of the Canterbury coast and plains, with a particular focus on the influence of Quaternary climate change, and to develop their observational and interpretive skills. The VFT combines narrative text and guiding questions with interactive maps showing aerial imagery of the landscape which include photos, GIS layers, and 3D models of the topography of select sites.

This study adds to the growing body of literature on the impact of VFTs on tertiary field education by evaluating and reflecting on our experiences developing and delivering the SOSC223 VFT, alongside student experiences attending the VFT.

1.3 Aims, objectives, and research questions

The overarching aim of this research is to evaluate the VFT developed and delivered for SOSC223 during the 2021 national lockdown and understand where it succeeded and fell short compared to a traditional field trip. To achieve this aim, I endeavoured to describe and understand the instructors' experience developing and delivering the VFT, students' experiences using the VFT, and to identify strengths and weaknesses of the VFT. These 3 objectives led to the following research questions:

- RQ 1: What are student and instructor perceptions of the SOSC223 VFT?
- RQ 2: What are the strengths and weaknesses of the SOSC223 VFT?
- RQ 3: How does the SOSC223 VFT compare to TFTs in tertiary earth science education?

1.4 Thesis structure

In Chapter 1 I have introduced the global context in which this research is occurring by providing an overview of COVID-19 pandemic response in Aotearoa New Zealand and its

impact on tertiary instruction. I outline the relevance of field trips to earth science education and provide the aims, objectives, and research questions guiding this project.

In Chapter 2 I expand on the importance of field trips in tertiary earth science education with a literature review of traditional and virtual field trips.

In Chapters 3 and 4 I establish the context of the research. In Chapter 3 I discuss the methodology and qualitative methods I follow and introduce myself as the researcher. Chapter 4 provides an overview of the course SOSC223, the field trips that became the VFT, and the process to designing the VFT exercises.

In Chapter 5 I address each research question, presenting both the *results* of interviews and qualitative analysis and *discussion* of the results to answer and elaborate on the research questions. I conclude the chapter by outlining how to improve the SOSC223 VFT and suggesting approaches for incorporating VFTs within curriculum.

Chapter 6 concludes with a summary of the research process and key results. I address limitations to the project and present avenues for further research.

Chapter 2

Literature Review

In this chapter I review the literature on the use and value of field trips in undergraduate-level earth science education and the challenges to running trips successfully. I then introduce virtual field trips as a controversial addition to traditional field trips and outline the best-practice suggestions from the literature. I discuss the types of research methods and methodologies employed in VFT educational research to provide rationale for the methodology I chose for this thesis.

2.1 Field trips in earth science education

Field experiences have long been valued within earth science education by students, instructors, and industry professionals alike (Petcovic et al., 2014). Field instruction develops students' identities and inducts them into communities of professional practice through providing authentic embodied experiences in a formative social setting, leading to measured and theorised positive cognitive, metacognitive, affective, and behavioural outcomes (e.g., Elkins & Elkins, 2007; Kern & Carpenter, 1986; Mogk & Goodwin, 2012; Stokes & Boyle, 2009).

One value of field trips lies in enculturating students into the values, skills, and behaviours of the discipline (Mogk & Goodwin, 2012; Petcovic et al., 2014). The field inducts students into their field of study through teaching ways of thinking and ways of doing. Students learn scientific skills and techniques like sampling methods, observation, and field sketching as well as how to communicate field data in meaningful ways (Mogk & Goodwin, 2012; Petcovic et al., 2014). Field experiences reinforce fundamental concepts (Elkins & Elkins, 2007; Kern & Carpenter, 1986) and develop student's self-efficacy and decision-making skills in complex and collaborative environments (Perry, 2004; Stokes & Boyle, 2009). Using bedrock geology as an example, Mogk and Goodwin (2012) illustrate how students' embodied experiences in the field lead them to learn and use professional scientific language and tools. Through bedrock mapping, geology students observe the environment, measure and record spatial data, and synthesise these with their existing understanding to interpret the boundaries and orientation of rocks in the landscape. Working collaboratively and guided by staff, students start to approach field work as a professional would and gain

insight into the strengths and limitations of the tools experts use to communicate information about the landscape (Mogk & Goodwin, 2012).

Authentic, embodied experiences in the field, such as bedrock mapping illustrated above, are linked to an increase in deeper learning. Students value learning by doing and report deep learning from field activities (Fuller, 2006; Stokes & Boyle, 2009). Stokes and Boyle (2009) observed students' behaviour reflected this attitude; students showed increased confidence and decision-making skills as a result of embodied activities. Comparing learning between short field trips and classroom laboratories, Kern and Carpenter (1986) found both to be equivalent for low-level knowledge gain (e.g., memorisation), but field trips increased deeper learning. They propose this is due to the integrated, experiential nature of the field trips. In the field, students use all their senses to observe and interpret the place around them, gain an appreciation of complexity, and put theory into practice to deal with that complexity and make sense of the landscape. Mogk and Goodwin (2012) draw on this "practitioner's wisdom" alongside cognitive theories to argue that field work is inherently embodied, where movement and gesture help to increase student learning and self-efficacy, and the more-memorable full sensory experience leads to affective gains that further support student's growth and learning.

Field trips provide an important social setting for developing interpersonal skills, relationships and identity within the discipline, which increases enjoyment and learning. Not only do students place high value in the social experiences of field trips (Boyle et al., 2007; Fuller, 2006; Petcovic et al., 2014; Stokes & Boyle, 2009), collaboration reduced anxiety students felt towards autonomy and decision-making in the field (Stokes & Boyle, 2009), and increased students' enjoyment of field activities, resulting in increased motivation and engagement (Fuller, 2006; Jolley et al., 2018; Stokes & Boyle, 2009). Does the social setting of field trips benefit more than just the affective domain? Many argue yes. The collaborative nature of fieldwork provides an authentic environment for social learning and developing scientific communication and collaborative skills expected by industry (Perry, 2004), and is an ideal setting for formative feedback (Jones & Washko, 2021; Kent, 1997; Mogk & Goodwin, 2012). Field instruction is a less formal environment that allows easier communication among students and between students and instructors. Instruction may take the form of informal apprenticeships, where instructors model expert behaviour for students to imitate and develop familiarity with professional practice (Lonergan & Andresen, 1988).

Students can easily ask staff questions and seek prompt feedback on their techniques or comprehension in an authentic, real-world context (Jones & Washko, 2021; Mogk & Goodwin, 2012). In turn, instructors can observe students' behaviour and modify instruction on the fly to correct misconceptions as they form or guide students towards more expert understanding (Mogk & Goodwin, 2012).

Despite the benefits associated with field trips, there are challenges to running them effectively. Costs and logistics are long-standing issues (Kent, 1997), with concerns that larger class sizes, health & safety pressures, greater costs, budget cuts, and time constraints have and will reduce the quantity or quality of undergraduate field excursions (Boyle et al., 2007). Equity in geoscience education is another growing concern, where the tradition of how field trips and field work are structured disadvantage those who do not fit a certain demographic (Atchison & Libarkin, 2016; Hall et al., 2004). By default, students are expected to be able-bodied, willing and fit enough to work in difficult physical conditions, know what constitutes appropriate field gear and be able to purchase it, and to have enough money and time to afford attending field trips or courses.

Boyle et al. (2007), though concluding the act of doing field work reduced students' anxiety and increased their confidence, found that many students initially reported high levels of anxiety towards field work. Anxiety and unfamiliarity can impact students' learning and enjoyment in the field by detracting from their ability to make sense of new environments (Orion & Hofstein, 1994). Orion and Hofstein (1994) found that students' learning and confidence in the field is impacted by their familiarity with the location, content, and previous outdoor experience. They outline the concept of *novelty space* with regards to field trip preparation, where a student's novelty space depends on their background understanding of relevant curriculum, their familiarity with the geographic location of the field trip, and knowing what to expect from the field trip day to reduce anxiety of the trip itself. If instructors do not adequately prepare a class for the field trip and reduce the novelty of the learning environment, the high cognitive load of being immersed in a new environment can detract from field learning (Orion & Hofstein, 1994).

Virtual field trips (VFTs) are one suggested tool to reduce novelty space and address the logistical and accessibility challenges of traditional field trips (TFTs).

2.2 Virtual Field Trips

Computerised virtual field trips (VFTs) have existed for more than 30 years (Hurst, 1998) and span a broad range of designs and structure. Sometimes referred to as virtual field "guides" or "experiences", VFTs are commonly created for use on a desktop computer and designed through an existing software or platform (such as Google Earth or Esri StoryMaps) or developed as an independent website, though some are developed for virtual reality (VR) systems and require VR headsets and consoles.

The structure of VFTs vary between linear and open exploration (Dolphin et al., 2019), with varying amounts of structure and interactivity. VFTs generally include a combination of narrative text with multimedia and guided exercises or questions to answer. Multimedia may include video, figures and diagrams, photos, aerial maps, other spatial data such as GIS layers of geology, soils, vegetation, or georeferenced data points, and embedded sections of, or hyperlinks to, external information. At their most basic, a VFT aims to replicate some of the visual experience of a traditional trip (Mead et al., 2019), often serving as an introduction to the field site (Cliffe, 2017). Stainfield et al. (2000) propose a best-practice VFT should facilitate learning and reinforcing skills through interaction by participation, exploration, and analysis – moving beyond a simple visual replication. This proposal holds weight 20 years later, with more VFTs designed for interactivity and immersion. Some educators achieve this with VR (e.g., Klippel et al., 2019; 2020; Markowitz et al., 2018), others, by incorporating 3-D models, panoramas, rich spatial data, and adaptive feedback into desktop experiences (Barth et al., 2022; Bond & Cawood, 2021; Mead et al., 2019; Pugsley et al., 2022; Watson et al., 2023).

Generally, VFTs are considered to be effective tools for learning, and have been shown to be equivalent to TFTs for knowledge gain (Cliffe, 2017), or to meet their learning outcomes (Bond et al., 2022; Mead et al., 2019). VFTs provide a number of opportunities where they can excel, though also present challenges. Many of the benefits and drawbacks of VFTs identified by Hurst (1998), an early adapter of using VFTs in geoscience education, hold true today. Table 2.1 outlines the features Hurst identified.

Logistical benefits inherent to virtual trips include reduced travel cost and time (Hurst, 1998; Stumpf et al., 2008; Whitmeyer & Dordevic, 2021) and associated reduced carbon emissions (Seifan et al., 2020), and being independent of weather (Stott & Nuttall, 2010) or physical

dangers (Hurst, 1998). Students can work at their own pace and revisit sites as often as they wish (Arrowsmith et al., 2005; Stott & Nuttall, 2010). VFTs are geographically independent and can take students to places far away or in ecologically fragile or harsh environments (Qiu & Hubble, 2002). Together, these benefits foster an accessible learning environment, a long-identified challenge in geoscience education (Feig et al., 2019; Hall et al., 2004).

Table 2.1 Modified table of the advantages and drawbacks to VFTs as identified by Hurst (1998).

Advantages to VFTs	Drawbacks of VFTs

• Can display
  ○ Multiple scales
  ○ Non-observable data
  ○ 3D features
• Flexible and repeatable
• Physically accessible
• Remove logistical concerns (e.g., travel, food)
• Remove risk of negative environmental factors (e.g., weather, fauna)
	• Abstraction of reality
	• Reduced sensory experience
	• Limited interaction
	• Limited opportunities for feedback and guidance

Educational opportunities arise from how instructors use various virtual mediums, including being able to be creative with scales in space and time or the types of content woven into the experience. Spatiotemporal scale might include showing seasonality and landscape change (Cliffe, 2017), or views at landscape, field site, and hand specimen (e.g., Arrowsmith et al., 2005; Dolphin et al., 2019; Pugsley et al., 2022), and even microscopic scales (Peace et al., 2021). Content can add context difficult or impractical to provide on a TFT, for instance, including a cross section of the geology of the landscape, or a schematic diagram of the inside of a mountain (Klippel et al., 2020); or, using interactive digital maps with GIS layers such as DEMs (digital elevation models), soil, geology, vegetation cover, or georeferenced points of field data (e.g., Evelpidou et al., 2022; Ramasundaram et al., 2005).

However, VFTs are an abstraction of information, and while they have potential to provide interactive learning environments on par with TFTs, VFTs lose embodiment and all the senses of physically being in the field (Arrowsmith et al., 2005; Stott & Nuttall, 2010). While students can potentially gain more ability in, for example, digital literacy and data analysis on a VFT than a TFT, it is difficult to teach field-specific skills like sampling methods (Bond et al., 2022; Peace et al., 2021; Whitmeyer & Dordevic, 2021). VFTs also miss out on the social side of field trips; many conclude students find it harder to build teamwork skills, get to know their peers or instructors, or ask quick questions on a VFT than when everyone is together in the field (Klippel et al., 2020; Stott & Nuttall, 2010; Stumpf et al., 2008). Even the benefit of increased accessibility is not assured. As cautioned by (Carabajal et al., 2017), VFTs

need to be designed to promote engagement through interactivity and immersion; VFTs are costly and time-intensive to create well (Cliffe, 2017; Jacobson et al., 2009; Stainfield et al., 2000).

2.2.1 Approaches to evaluating VFTs

Research on VFT development and use in earth science education generally follows a mixed-method approach, gathering and analysing a mix of quantitative and qualitative data from the students or staff involved in running a VFT. Quantitative methods take the form of pre/post-tests, which capture the change in what is assessed through comparing responses before and after the intervention (i.e., the VFT). Some utilize this design to explore changes in student or staff perception before and after a VFT (e.g., Bond et al., 2022; Race et al., 2021) and many more use pre/post-tests to assess knowledge gained (e.g., Hurst, 1998; Markowitz et al., 2018; Mead et al., 2019; Puhek et al., 2012; Sriarunrasmee et al., 2015; Stumpf et al., 2008; Watson, 2019). While most studies do not directly compare their VFTs with any other intervention, simply establishing students have learned due to the VFT, Hurst (1998) compares knowledge gained from a VFT with in-person laboratories and Puhek et al. (2012) directly compare their traditional and virtual trips.

Straddling the border between quantitative and qualitative methods, closed question questionnaires provide a way to at least partially quantify qualitative measures like preferences and experiences. Most studies include surveys within their design, using 5 point Likert scales or tick box questions to gain basic insight on topics including perceived learning, motivation, preference, and enjoyment (e.g., Arrowsmith et al., 2005; Bond et al., 2022; Friess et al., 2016; Jacobson et al., 2009; Race et al., 2021; Seifan et al., 2019; Spicer & Stratford, 2001; Stott & Nuttall, 2010). Often these ordinal data are supplemented with space for participant commentary or open questions asking for feedback on the experience. This richer qualitative data is of limited scope in many of these studies and used to support the ordinal results or included within general summaries of the authors' reflections on their VFTs (e.g., Arrowsmith et al., 2005; Friess et al., 2016; Spicer & Stratford, 2001; Stott & Nuttall, 2010). However, some studies gather enough qualitative data through open reflective questions to thematically code student responses (e.g., Bond et al., 2022; Klippel et al., 2020; Mead et al., 2019; Watson, 2019).

Qualitative methods employed in the literature vary in formality, from informed but informal reflection (Barth et al., 2022; Hurst, 1998; Jacobson et al., 2009; Ramasundaram et al., 2005; Stott & Nuttall, 2010), summaries of instructor observation of student workflow and engagement (Dolphin et al., 2019), to explicit thematic analyses of student reflective essays (Jacobson et al., 2009; Stumpf et al., 2008), journals (Race et al., 2021), assignment responses (Watson, 2019), and thematic analyses of observation and interviews as part of an ethnographic case study (Race et al., 2021). Studies that employ a more qualitative methodology have different (though complementary) research objectives and outcomes to their quantitative counterparts. Quantitative knowledge tests and ordinal survey responses target the *whats* of VFTs as an educational experience (does knowledge gain occur? What are student and staff's general perceptions?). Qualitative methods and methodology, such as the ethnographic case study employed by Race et al. (2021), instead afford insight into the *whys* and *hows* behind the experience or phenomenon being studied by allowing analysis of data such as communicated perceptions, lived experiences, beliefs and conceptions (Feig, 2011); the analysis can centre student voices (Race et al., 2021).

2.2.2 Summary and argument for methodology

The literature on VFTs establishes that learning occurs and provides basic insight into participant's perceptions and attitudes towards VFTs. However, much of the discussion of the strengths and challenges of VFTs is practitioners' wisdom - informed but informal reflection on ordinal data and informal observation. Similar to Race et al.'s (2021) study to understand what was lost and gained in their rapid conversion of a field course to online, I wanted to evaluate the SOSC223 VFT through exploring participants' experiences. Qualitative methodology allowed me to gather rich detail on participants' experiences and gain context and insight into the challenges and successes of the VFT.

Chapter 3

Methodology

As covered in chapter 1, this study investigates the lived experience of the instructors and students in an undergraduate geomorphology course creating, delivering, and attending a VFT during the 2021 Covid lockdown. In this chapter I justify the methodology underpinning this research and the methods I followed, beginning by introducing qualitative research methodology and case study research and defining the bounds of this case study, then outlining the methods of sample selection, data collection and the ethical considerations involved therein, and analysis used to provide evidence for the three research questions - to holistically describe student and instructor experiences and perceptions of the SOSC223 VFT, ascertain the benefits and challenges of using the VFT, and suggest how the VFT compares to traditional field trips in earth science education. I end this chapter by discussing how to conduct rigorous qualitative research and address my own bias and assumptions going into the study.

3.1 Qualitative research methods

At the time I began this project, existing research on VFTs either measured student learning gains through pre and post-tests, attitudes or low-detail experience with Likert surveys or informal reflections, or presented practitioners' wisdom on theoretical benefits and weaknesses of incorporating virtual trips into an earth science course. There was little detailed investigation into the experiences of those developing, delivering, and attending a VFT that could provide evidence for practitioners' wisdom or begin to inform the whys and hows behind particular strengths, weaknesses, or general experience. Covid lockdown both allowed and forced upon me the opportunity to explore this experiential space.

Qualitative case studies are a common method to gain detailed insight into a specific experience. A case is particularistic, by focussing on a particular situation; descriptive, by yielding rich description of the phenomenon; and heuristic in that it illuminates the readers' understanding of the phenomenon (Merriam & Tisdell, 2015; as cited in Yazan, 2015). The case is a bounded system with a limited number of potential participants. In this study, the case is a combination of the course - SOSC223 *Physical landscapes: formation and function*, with the education activity - the emergency VFT, and those who created and attended it -

myself, the course examiner, and the students enrolled in SOSC223 in 2021. The methods I follow are drawn from Merriam and Tisdell's (2015) approach in Qualitative Research: A Guide to Design and Implementation and Lofland and Lofland's (1995) Social Settings: A Guide to Qualitative Observation and Analysis.

In general, qualitative research aims to understand people's experiences and the meanings behind them. As Merriam and Tisdell (2015) write in Qualitative Research: A Guide to Design and Implementation:

> Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences. (Merriam & Tisdell, 2015, p. 6).

This is an interpretive and constructivist approach, which assumes that reality is socially constructed - at least to some extent. Instead of the positivist approach common to experimental research where researchers assume a single, repeatable, observable truth, qualitative researchers working in a constructivist framework interpret and construct knowledge and understanding (Merriam & Tisdell, 2015). It is an inductive process - results emerge from being immersed in the data, and the researcher is the primary instrument for both data gathering and analysis.

3.2 Sample selection

The goal of case study research is not to develop statistically generalizable results through probability sampling. Instead the aims are *intrinsic*, documenting a unique situation for its own sake out of intrinsic interest in the case, *instrumental*, using the case to add to the knowledge base for others, or combine elements of both (Stake, 1995). To meet these aims, a researcher must select an information-rich sample "from which the most can be learned" (Merriam & Tisdell, 2015, p. 96), following a purposeful sampling strategy. Merriam and Tisdell (2015) suggest a two-tier purposeful sampling method for case studies - first choosing the case to be studied, then determining selection criteria for sampling within the case.

As I mention previously, the case in this study is the experience of people involved with the SOSC223 VFT during lockdown in 2021. The selection criteria - the crucial attributes of a sample - mostly relate to whether participants experienced the VFT. For students, selection criteria include:

- Participants must have been enrolled in SOSC223 in 2021, and,

- Participants must have attended the VFT.

For teaching staff, selection criteria include:

- Participants must have taught into SOSC223 in 2021, and,
- Participants must have been involved with making and delivering the VFT.

Additional sample selection criteria relate to the ethical considerations involving undergraduate participants and my role as instructor and research. These include:

- Student participants must give specific consent to include their items of coursework in the analysis, and
- Samples involving student participants must be able to be collected after the date the Ethics Committee approved for data collection to begin.

I describe the ethical concerns these criteria relate to in more detail in the following subsection on data collection.

Following these sample criteria, the possible sample size was a maximum of 8 students who submitted their VFT assignments out of the 9 enrolled in 2021, the course examiner who co-created and ran the VFT with me, and myself, the course tutor. This leads to the following data collected and analysed:

- Audio recordings and typed transcripts of semi-structured interviews with 5 student volunteers and 1 course examiner,
- My researcher notes and memos from the interviews,
- A self-interview, and
- My reflective journaling from lockdown.

3.3 Data collection – Interviews

Frequently, qualitative case studies gather data from a combination of observations and interviews, or documents. Due to the constraints of lockdown, I was unable to systematically observe how participants worked on the VFT. As such, the data for this case study is limited to that gathered through one-off semi-structured interviews, although in an ideal world it would be advantageous to include follow-up interviews and participant observation.

3.3.1 Semi-structured interviews

Of the various types of interviews used in qualitative study, semi-structured interviews (SSIs) are the most widespread (DiCicco-Bloom & Crabtree, 2006). Although time and labour intensive, SSIs are a flexible tool that lets the interviewer ask probing open-ended questions which are beneficial in gaining in-depth information on individual participants' experiences or views (Adams, 2015; Kallio et al., 2016).

Interview questions are developed as part of an interview guide prior to interviews. The interview guide outlines key topics and questions to address. Unlike structured interviews, with semi-structured interviews the interviewer can improvise follow up questions based on a participant's response or skip over questions that a participant has already addressed. This allows for a flexible interview style and opportunity to explore participant responses in greater depth (Adams, 2015; Kallio et al., 2016).

The student interview guide had 5 key sections, intending to learn about students' perceptions and experiences with traditional field trips, what they expected from the VFT, how they worked on the VFT, their perceptions of and attitude towards the VFT, and judgements of how, when, and if they'd want future VFTs in their courses. The instructor interview guide was overall similar to the student guide, with additional questions on the purpose of the trips in the course, our experience developing the VFT, and perceptions of students' engagement and learning from it. The interview guides are available in Appendix B. Before beginning the interviews, I ran through two practice runs with colleagues and made changes for flow and clarity. Refining the interview guide was an ongoing process, as Adams (2015) suggested it would be. After beginning the participant interviews, my guide changed in small ways to pursue interesting topics emerging from the first few interviews and to fix confusing questions.

I began each interview by introducing the purpose of the interview and study and broke the ice by briefly chatting about students' experiences at Lincoln University - what they're interested in, what they're studying or have enjoyed. I roughly followed the order of sections in each interview, deviating more as I became more comfortable interviewing. The depth of students' responses was hampered by my inexperience; I was not as responsive as I would like to have been and stuck too rigidly to the document. There were instances where I could have followed up on points students made to gain richer insight into their experience, and

some of the questions I included were redundant in practice, even though they intended to elicit subtly different responses. The final interview with the examiner was better in this respect. It was in-person, which I found easier than over the phone or Zoom, I had more experience conducting interviews, and perhaps most importantly, the examiner has ample experience being interviewed and did not hesitate to provide detail, ask me clarifying questions, or return to previous points if he found he had more to say. His experience balanced out my own relative inexperience.

3.3.2 Ethical considerations

This project was reviewed by the Lincoln University Human Ethics Committee, prior to commencing interviews. A significant ethical consideration concerned my role as the SOSC223 tutor. Other identified and mitigated risks included issues of privacy, distress, and time.

The largest identified risk was due to my position as both instructor and researcher. To ensure that students did not feel pressured to participate, or that their course assessment was in any way tied to their participation, I only conducted interviews between December 2021 and February 2022, after the semester ended and final marks were released. I attended students' last lecture in SOSC223 in 2021 to introduce this project and provide them an opportunity to participate, stressing that it was voluntary and I would be interviewing any participants as a fellow student rather than an instructor. I then emailed the class a research information sheet further outlining the goals of the project, what their participation would involve, and how their data would be kept secure and confidential. For those who volunteered to participate, I scheduled with them a 1 hour meeting for an up-to 1 hour interview over the phone or Zoom.

Student privacy was managed by saving all recorded data - including consent forms, recordings, transcripts, and notes in a password protected folder only I had access to, assigning students code-names for use in any publications, and ensuring any quotes or descriptive data does not include identifiable information. Interviews were only recorded after receiving written and verbal consent.

This research involved asking participants about their experiences during Covid lockdown - a stressful time for everyone. We mitigated the risk of distress by trying to keep a student-focus in the interviews. I assured participants at the start of the interviews that any

questions they did not want to answer they did not need to, and paid attention to their emotional state throughout to be ready to shift topics, pause, pause the recording, or otherwise empathetically engage if needed, though no participants did.

The interviews were scheduled to take up to 1 hour during students' summer break, at a time they chose. Each student was offered a $20 gift voucher to recognise their time.

Ethical documentation, including committee approval, research information sheets, and consent forms are in Appendix A.

3.4 Data analysis

My data includes transcribed interviews, my notes and memos of the interviews, and my reflective journaling from lockdown. I organised and analysed digital documents using a combination of Microsoft Word and NVivo, a qualitative data analysis software program. I transcribed audio recordings of the interviews in Word and did initial coding using the highlighter and comment functions in Word, shortly after conducting the interview. Once I open coded and annotated each interview, I exported the marked files as .pdfs and opened them in NVivo to more easily collate these initial, open codes. I grouped similar codes and began to define them and consider what they represented. I did this analytic coding focussed on emerging themes that were relevant to my research objectives or frequently occurring enough to have import. This was an iterative process with many stops and starts as I learned how to better analyse the transcripts - the qualitative data. After developing a coding scheme that addressed the research questions, I returned to the full transcripts and coded them a last time, using just the coding scheme.

This is the basic process of the constant comparison method, developed by Glaser and Strauss (1967) for grounded theory, and widely adopted throughout qualitative research (Merriam & Tisdell, 2015). The goal of analysis is to make sense of the data by "consolidating, reducing, and interpreting what people have said and what the researcher has seen and read" (Merriam & Tisdell, 2015, p. 202). It is an iterative and inductive processes where the researcher cycles between data and abstract concepts, inductive and deductive reasoning, and description and interpretation to develop categories - *themes* - that answer the research questions. Merriam and Tisdell (2015) suggest the process of category construction begins with *open coding*, where the researcher highlights, annotates,

and takes notes on their first transcript shortly after the interview to ID anything that might be useful. They repeat this with the next transcript and compare it with the first, noting similarities and differences in codes. Then they merge codes and repeat with the next transcript. After open coding, the researcher begins *analytic coding* by grouping similar data into categories. The resulting themes both describe and interpret the data as the results of the study.

Depending on the purpose of the study, the results may be organised descriptive accounts or themes that cut across the data, or interpretive models or theories that further explain the data (Merriam & Tisdell, 2015). In this study, the findings are descriptions of the case and context and themes, not theories.

3.5 Validity and reliability

Like all research, interpretive qualitative research is concerned with ethically producing valid and reliable knowledge. Instead of trying to demonstrate rigour through producing repeatable and statistically generalizable results, most qualitative research builds trustworthiness through different conceptions of validity and reliability (Merriam & Tisdell, 2015). Internal validity, sometimes called credibility (Lincoln & Guba, 1985), refers to how well findings represent the "reality" of what is being researched. Reliability, or consistency (Lincoln & Guba, 1985), concerns whether the results are consistent with the data collected.

To increase validity and reliability, researchers can use strategies like triangulation, member checks, data collection until saturation, and providing enough context for the reader to be satisfied that the methodology and methods support the researcher's conclusions by including rich description of the setting and results, relevant background and biases of the researcher, and of the analysis process.

Data triangulation is a strategy to collect consistent and dependable data that is aligned to reality (Merriam & Tisdell, 2015). Triangulation can be done in various ways, including for example using multiple methods of data collection, multiple data sources, or multiple investigators (Denzin, 1978). Essentially, the more different data or types of data the researcher collects that supports each other, and the more people agree on interpretations, the more likely that data is representative and the interpretations are credible. In this project, I triangulate with multiple methods and sources, using interviews and reflective

journaling as two methods and including both student participants who experienced attending and using the VFT and staff participants who created and delivered it. While I would have liked to further triangulate data through including observation and researcher triangulation, the constraints of lockdown and the time and logistical constraints on this project made conducting observations unethical and getting other eyes to analyse the data impractical.

Member checks are where the researcher takes their preliminary interpretations - their results - back to participants to check that they have captured participants' intended meaning (Merriam & Tisdell, 2015). I was unable to stay in contact with the student participants; however, the course examiner has reviewed my interpretations of his interview.

Data saturation occurs when the researcher has engaged enough with the data to find no new themes and further data collections or analysis corroborates existing results without adding further insight (Lofland & Lofland, 1995; Merriam & Tisdell, 2015). Data saturation is a weakness of this research - 6 participants and 1 participant-researcher is a very small sample size, and was a hard limit set by the nature of this case study and when and how I was able to collect data. To mitigate this, I have focussed on themes that did reach saturation and aimed to cover them as richly as possible through thick description.

The intent of case study research is not to be generalizable - where quantitative research is concerned with generalisation and transferability, qualitative research tries to provide enough detail for the reader to logically follow and come to the same conclusion as the researcher (Lincoln & Guba, 1985; Merriam & Tisdell, 2015). I aim to achieve this through thick (detailed) description of the case, disclosing my biases and assumptions, and detailing my analysis.

3.6 Researcher bias and assumptions

I come from a background agreeing with Boyle et al.'s (2007) assumption that "fieldwork is good". This was my experience as an undergraduate geoscience major - my most memorable learning experiences occurred on field trips or doing field work. This has also been my experience as a tertiary laboratory instructor - students appear to value field trips and make sense of the course material and the overarching story of the landscape on field trips in a

way they do not in lectures or computer labs. Even understanding some of the limitations of traditional trips, I value field education as a student and instructor.

The discipline of geoscience has basis in a positivist tradition. Feig (2011) states “The ‘laws’ of physics and chemistry underlie every Earth process, and those processes are investigated through hypothesis, experiment, observation, and subsequent hypothesis revision/rejection” (p. 3). While I agree in part - the former is not wrong and my background does lead me to consider science and understanding through the view of logical empiricism, I think this take ignores the interpretive tradition of geoscience and the value towards interpretivism tacitly held in the discipline, especially around fieldwork. Frodeman (1995) argues that while geoscience in part depends on the logical empiricism of experimental science, geologic reasoning is also a hermeneutic, meaning interpretive, and historical science, where natural processes are interpreted to explain and understand past events in Earth's history. Much geologic understanding involves iterative reasoning, where, as described by Frodeman:

> Our understanding of a region is based on our interpretation of the individual outcrops in that region, and vice versa; and our interpretation of an individual bed within an outcrop is based on our understanding of the sediments and structures that make up that bed, and vice versa. (Frodeman, 1995, p. 963)

Further, in the narrative logic of geologic reasoning, the outcrop adds to the overarching story the geologist tries to tell.

> It is characteristic of their discipline that geologists tell a story that gives a larger context and meaning to their research. (Frodeman, 1995, p. 966)

This creation of knowledge through narrative and iterative logic combines multiple streams of data from different tools and requires evaluation of possible and plausible interpretations of data in line with accepted knowledge and theory to tell a sensical story supported by the data and reasoning. So, while the qualitative methods I use in this study were new to me, I am familiar with the underlying philosophies of interpretivism and the role of iterative reasoning and narrative logic used to construct and communicate knowledge in the field.

I was intimately involved in all aspects of this research. I co-created the VFT with the course examiner, ported all sections into StoryMaps, organised Zoom tutorials for students, and marked students' associated assignments. Going into the interviews with my

aforementioned experience, I expected students to have dreaded the VFT. At the time they were assigned it, they appeared to find it confusing and a reluctant substitute for being able to attend in-person.

Chapter 4

Setting and context

Chapter 4 provides context for the SOSC223 VFT, beginning with an overview of relevant aspects of SOSC223 *Physical landscapes: formation and function* and the geologic history and geomorphology of the Canterbury Plains and coast as the area visited on the VFT. This is followed by a description of the examiner and my process developing the VFT, including why we used StoryMaps, the sites and exercises, and the logistics of delivery and assessment.

4.1 Course context: SOSC223 Physical landscapes: formation and function

SOSC223 *Physical landscapes: formation and function* is an elective second-year course in the Department of Soil and Physical Sciences at Lincoln University that is one of the core courses for the BSc in Environmental Science. It aims to provide students with fundamental geomorphic skills and concepts as a basis for further studies of land and soil resources and environmental hazards. Students are expected to develop knowledge of the history and processes of landform evolution with specific focus on Aotearoa New Zealand.

Three in-person field trips are an important component of the course, where students directly experience the landscape and observe many past and present landforms and processes shaping Canterbury. The first two trips combined investigate the evolution of the Canterbury Plains and coast as relating to the Quaternary glacial climate cycle and the third trip adds the effects of tectonic uplift on the landscape. The first two trips are relevant to this case study. Trip 1 is a half-day visit to Kaitōrete “Spit”, a barrier beach on the Canterbury coast. Trip 2 is a day-long tour travelling inland along the Rakaia River on the Canterbury Plains. In 2021, due to thunderstorms on the day, we postponed the first trip until the laboratory session the week before trip 2. We then went into Covid-19 lockdown and both trips 1 and 2 were cancelled. The course examiner and I chose to combine them into a single VFT in ArcGIS StoryMaps that we developed and delivered during lockdown.

4.1.1 Purpose of the Canterbury Plains field trips

Kaitōrete Spit and the Rakaia River are both parts of the Canterbury Plains, a large gravel apron with two main geomorphic drivers - the Southern Alps as a sediment source and the Pacific Ocean. The field trips explore how the Southern Alps and Pacific Ocean have

responded to Quaternary climate change and how the glacial/interglacial cycle has affected the behaviour of the glacial, fluvial, and coastal geomorphic systems on the plains, by looking at the type and morphology of the landforms present in these systems and how they have changed from the last glacial maximum to today. Additionally, the trips aim to relate the behaviour of the geomorphic systems to local land management practices. In the coastal system on Kaitōrete this is done by evaluating the management of water levels in te roto o Wairewa | Lake Forsyth, and in the Rakaia River fluvial system by looking at loess deposition and soil development on the higher river terraces at Barrhill. Table 4.1 shows the learning outcomes of the field trips.

Table 4.1 Aims and learning outcomes (LO) of the field trips to Kaitōrete Spit and the Canterbury Plains

Kaitōrete Spit field trip	
Aim	To enable students to comprehend how the interaction between Quaternary climate change, changes in sea level and coastal processes have influenced the Holocene geomorphic evolution of Te Waihora and Kaitōrete spit including changes in historic times, which influence environmental quality.
LO 1	Students will be able to explain the Holocene evolution of a "Te Waihora" embayment into a lake/lagoon phase with growth of Kaitōrete spit and its development into a barrier bar.
LO 2	Students will be able to explain how wave-driven coastal processes and their interaction with beach sediment have formed the current beach profile and its changes in morphology over time.
LO 3	Students will be able to apply their understandings from LOs 1 and 2 to debate management options for the coastal fringe especially with regard to water quality of the coastal lakes.
Canterbury Plains field trip	
Aim	To enable students to comprehend how the interaction between Quaternary climate change, glaciers emerging from the Southern Alps and river behaviour have influenced the geomorphic evolution of the Canterbury Plains and the soils on them.
LO 1	Students will be able to explain how the interaction between climate, glacial behaviour, sediment supply, and river behaviour have interacted to form the landforms and deposits associated with the Rakaia River segment of the Canterbury Plains.
LO 2	Students will be able to name and explain the origin and timing of the suite of landforms from glaciated parts of the Rakaia Valley to the associated plains.
LO 3	Students will be able to draw diagrams showing the stratigraphic relations of river deposits (alluvial fills) in the Rakaia River gorge and explain how the stratigraphy relates to the dynamics of the river.

4.2 Study area: Geology and geomorpholgy of the Canterbury Plains

4.2.1 Tectonic setting of NZ

Aotearoa New Zealand exists on the boundary between the Pacific and Australian plates, with markedly different tectonic settings along different sections of the plate boundary. Crustal extension and volcanism in the North Island is caused by the subduction of the oceanic Pacific plate below the Australian plate. In the southernmost South Island and further south, the Australian plate instead subducts under the Pacific plate. These opposing

subduction zones are linked by the Alpine Fault through most of the South Island, where the oblique convergence of the plates causes reverse strike-slip faulting along the Alpine Fault and uplift on the Southern Alps (Nicol et al., 2017 and sources within). The tectonic setting, climate, and erosion regime of the South Island are shown in Figure 4.1.

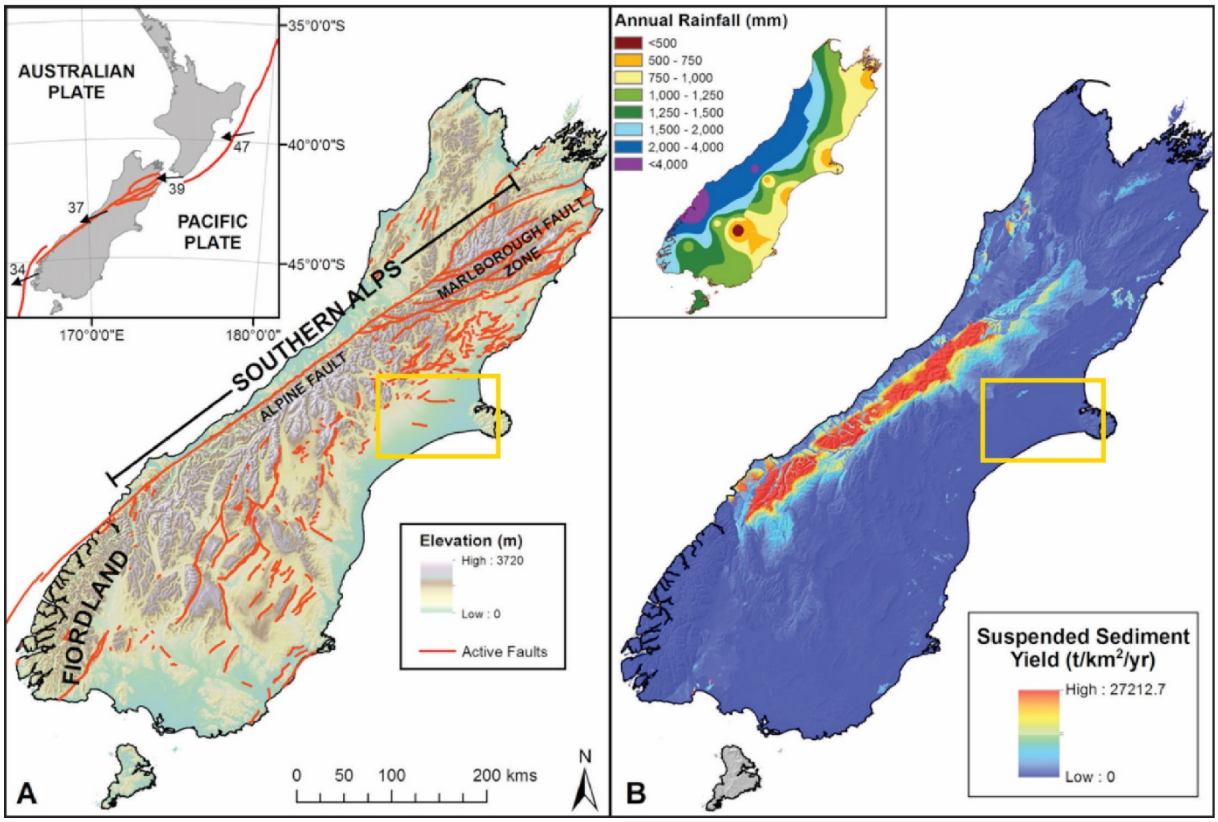

Figure 4.1 **A) Topography and active faults of the South Island, with an inset of the tectonic setting of New Zealand. B) Suspended sediment yield of the Southern Alps, with inset annual rainfall (Robinson et al., 2016, used with permission). The region of the Canterbury Plains visited on the SOSC223 field trips are labelled with a yellow box.**

4.2.2 The Canterbury Plains

The Canterbury Plains (Figure 4.2) are a low-gradient alluvial gravel fan extending from the eastern front of the Southern Alps to the Pacific Ocean and are the onshore part of the subsiding Canterbury Basin (Browne & Naish, 2003). The plains owe their existence to the interplay of tectonics and the Quaternary glacial/interglacial climate cycle. Uplift and erosion in the Southern Alps provides continuous sediment to the basin (Figure 4.1), the amount of which is controlled by the climate cycle. Sediment supply from the mountains increases during Quaternary glaciations, where colder temperatures lead to less vegetation cover and increased mechanical weathering (Soons, 1968). This results in increased erosion from the mountains and sediment transportation by glaciers and meltwater rivers, forming paired terminal moraines and aggradational outwash fans during glacial advances (Suggate, 1963).

Lacking the same supply of sediment in warmer interglacials, the braided rivers of the plains incise into the top of their fans to form steep terraces, and splay out over the glacial surface towards the modern coastline (Soons, 1968).

This repetitive climate cycle has formed flights of sediment in the stratigraphy of the plains. Near the coast and offshore, the stratigraphy alternates between marine sands deposited during post-glacial sea level rise and interglacial sea level highstands, with alluvial gravels deposited by rivers during the glacial lowstand sea levels (Brown et al., 1988; Browne & Naish, 2003). Towards the mountains, the gravel packages get older with depth and can be partially reworked in the succeeding glacial advance.

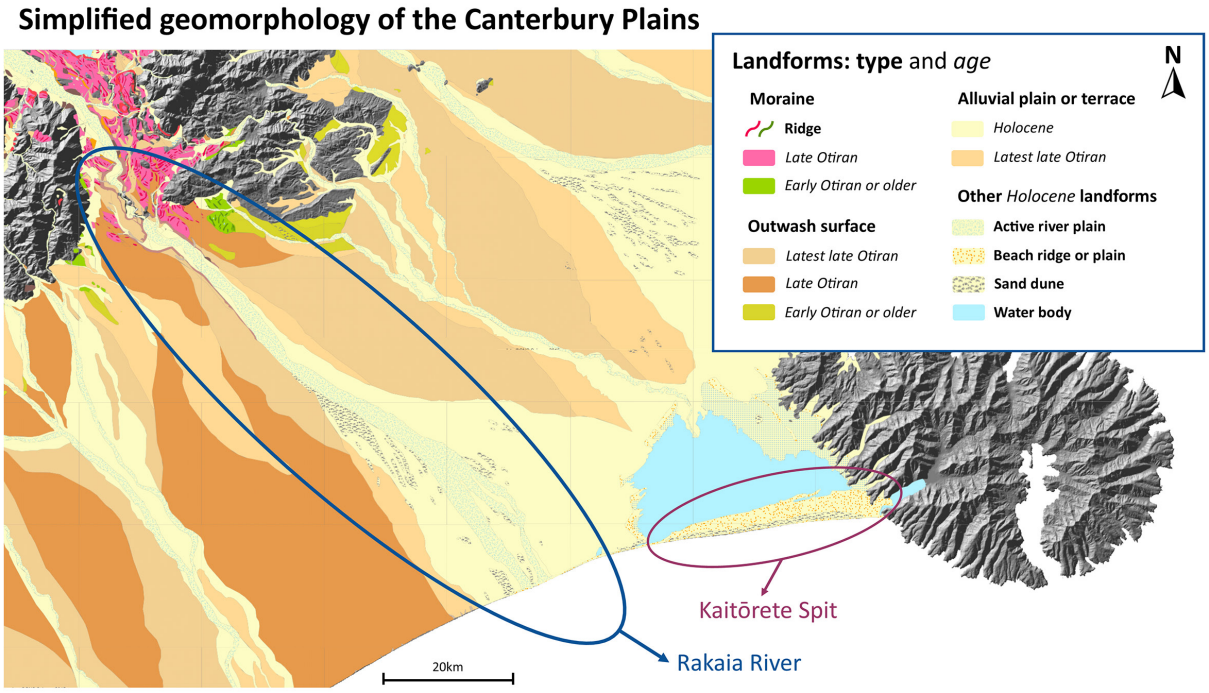

Figure 4.2 Geomorphologic map of the Canterbury Plains (adapted from Barrell et al. (2013), under the CC-BY license). The study areas visited on the SOSC223 field trips are circled in purple (Kaitōrete Spit) and blue (the Rakaia River).

4.2.3 The Canterbury coast

The Canterbury coastline is a dynamic environment with areas of erosional, progradational, and stable coast (Leckie, 2003). The dominant southerly swell causes net northward longshore drift. The southern section of the Canterbury coast, near the mouth of the Rakaia River, retreats ~1m/year (Gibb, 1978). This sediment is transported north by longshore drift, until it is blocked by Horomaka | Banks Peninsula and is deposited onto a prograding barrier, Kaitōrete Spit.

Te Waihora and Kaitōrete Spit

Te Waihora | Lake Ellesmere is a low-lying brackish lake separated from the ocean by Kaitōrete Spit, a spit/barrier complex. The evolution of Kaitōrete and Waihora is the story of the interplay of post-glacial sea level rise, coastal processes, and avulsions of the Waimakariri or Rakaia Rivers into and away from Waihora.

The land around and occupied by Te Waihora is lower in elevation than the surrounding plains. Beginning around 14,000 years ago, post-glacial sea level rise gradually flooded the land and formed an embayment (Soons et al., 1997). Sands and gravels were transported from the coastline further south to deposit hooked bars across the bay, forming a spit and lagoon system (Armon, 1974). When a large river, like the Waimakariri or Rakaia, flowed into the lagoon, it maintained an opening to the ocean and prevented the spit from welding to Horomaka | Banks Peninsula to the east. When the river avulsed, or shifted, away, the spit would close and the lagoon would become a lake. Continued sediment supply, with nowhere else to go, then built out barrier ridges, and a prograding barrier would begin to form and orient itself to be perpendicular to the dominant swell (Soons et al., 1997).

When the Waimakariri or Rakaia avulsed back into Te Waihora, the river would breach the welded spit and barrier and the system would return to a spit and lagoon. This is estimated to have happened at least 3 times since the formation of the first spit by approximately 8,000 years B.P. (Soons et al., 1997). The most recent spit welded to the peninsula roughly 500 years ago (Soons et al., 1997), and the current barrier developed.

4.3 VFT platform: StoryMaps

ArcGIS StoryMaps is a web application where users can create a “StoryMap” or “Story” by combining interactive maps with multimedia and narrative text to tell stories about the world. StoryMaps provides ready-to-use templates with multimedia “builders” where the user chooses what type of text, map, or external media to incorporate into their Story.

The examiner and I considered using Google Earth and ArcGIS StoryMaps as the platform for the VFT. We chose StoryMaps over Google Earth for a few reasons: Though we both were comfortable using Google Earth, I had previously used StoryMaps to create resources for an introductory earth science course and found it easier to quickly incorporate GIS maps than in Google Earth. Additionally, the available templates provided a more guided structure to the VFT compared to Google Earth. While some VFT-makers choose Google Earth for its less-

linear structure, we felt it would have required additional time and resourcing to provide students with enough support to work on semi-independently during lockdown, and expected that the structure of StoryMaps would benefit our situation.

4.4 VFT content and structure

The examiner and I began work on the VFT on August 20th, 2021 from our home computer setups. The materials we could access during lockdown included an archive of photos of the field sites taken on previous years' field trips, GIS shapefiles of soil and geology, base layer imagery used by ArcOnline, Google Earth web and street view imagery, and any published research and data on the locations. I focused on developing the Kaitōrete Spit sites and the examiner created most of the Canterbury Plains sites and wrote the introduction to the VFT. The entire VFT is publicly available to read at https://storymaps.arcgis.com/stories/79e6b81051cf42aa89434df0acfc960b.

4.4.1 Kaitōrete Spit sites

The main media panel in the Kaitōrete Spit sites includes a combination of interactive *web scenes* modelling the topography and imagery of the land surface, 2D *express maps* with location pins, text, and photos added to the map. A scrollable *side bar* to the left of the media panel adds narrative and directive text, additional photos, diagrams and explanatory video, and the site questions and exercises.

Each site of the Kaitōrete part of the VFT was structured similarly. Students were first directed to make and write observations of the landscape they could see from aerial imagery and photos included in StoryMaps and then asked questions to interpret those observations in context with natural processes or management practices occurring at the sites. At the end of a section, students were asked to reflect on what they had seen at the previous sites and to think about the larger story of the evolution of the spit/barrier complex. Refer to Figure 4.3 for an example of an initial observation exercise at the start of a site.

4.4.2 Rakaia River sites

Instead of relying on the web scenes and express maps of the Kaitōrete sites, the Rakaia River sites use a combination of higher-resolution 3D models of the site locations with clickable geospatial layers displaying soil and surface geology of the locations, an Earth Studio video animation to travel upstream, a 2D map connecting outwash surfaces with

terminal moraines, and Google Street View to explore a road-side outcrop. The narrative side bar works the same as for Kaitōrete.

The sites were structured as snapshots of the landforms on the plains, where individual sites aimed to get students to identify landforms and interact with the multimedia to learn about factors like landform age or sediment source, to describe spatial relationships, and to interpret how landforms developed. Figure 4.4 provides an example from the first Rakaia site. Combined, these sites attempted to tie together the story of the Quaternary evolution of the plains.

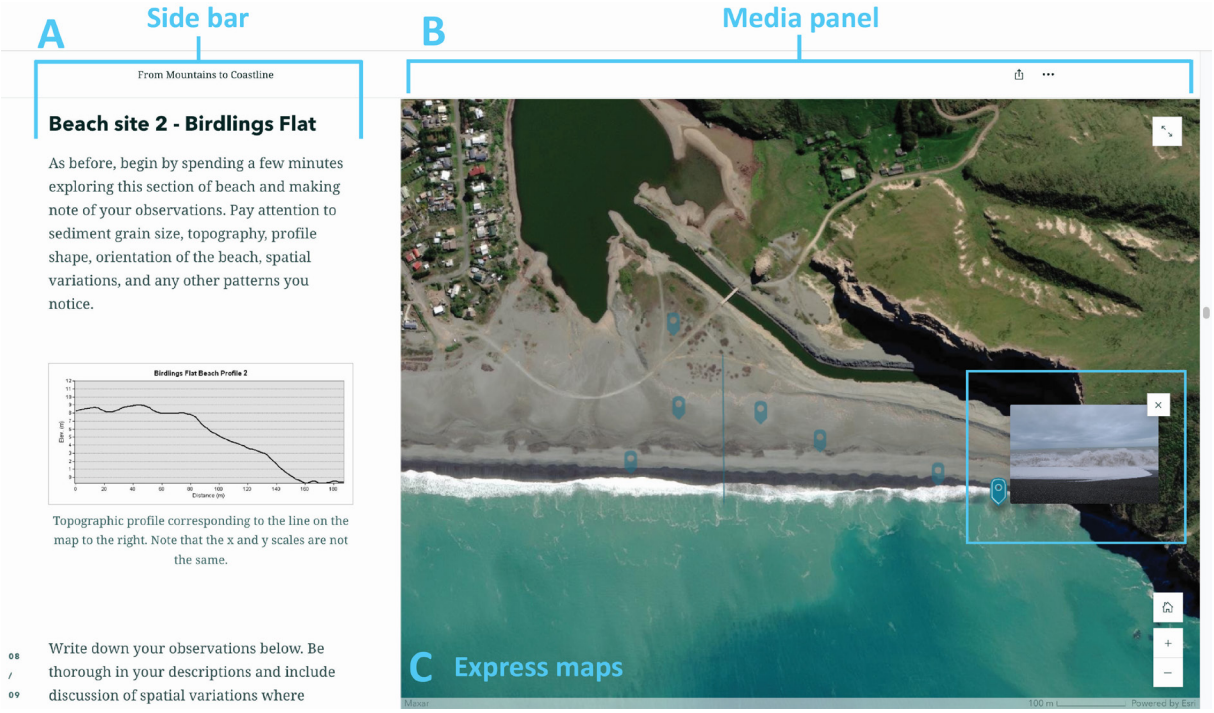

Figure 4.3 **Annotated screenshot of a Kaitōrete Spit site. Students are instructed to explore the photos and imagery in the media panel and note down their observations. A) *Side bar* containing text and small multimedia panels. B) *Media panel* for larger maps and multimedia. C) An example of an *express map* with location markers and imbedded photos of the landscape.**

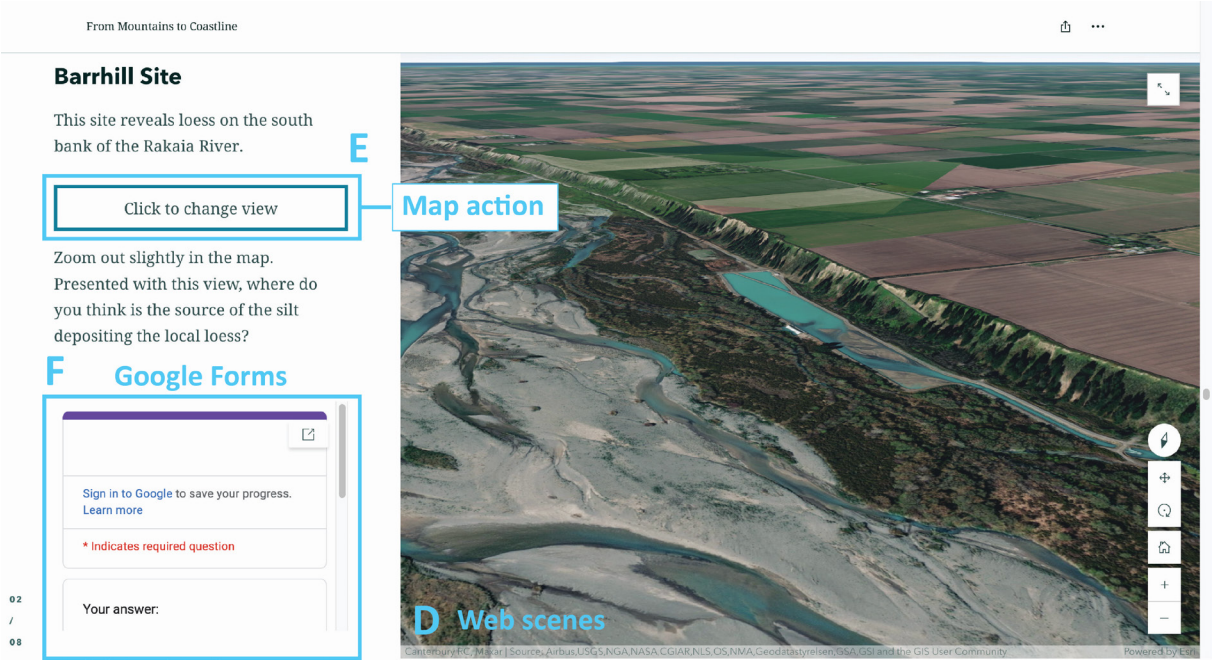

Figure 4.4 Annotated screenshot of the introductory exercise at the Barrhill site. Students are instructed to interpret the source of loess before they learn more about the site and interpret the history of loess deposition and soil formation. D) An example *web scene*, which provides a simple interactive 3D model of the landscape. E) The *map action* button changes the view in the media panel. F) Students submit their question responses to an embedded Google Form.

4.5 Components of the VFT exercises

The examiner and I aimed to build in as much interactivity into the VFT as we could. We used the *side car* template in StoryMaps and added the following components to the Story. Annotated screenshots of the StoryMap visually demonstrate each component of the VFT in Figure 4.3 and Figure 4.4 above and Figure 4.5 below.

Side car template and side bar

The majority of the VFT uses the side car template, which breaks the StoryMap into two panels. The larger panel on the right (Figure 4.3 B) allows users to add images, video, ArcOnline maps or scenes, create express maps, or embed external web content. The narrow panel on the left, or side bar (Figure 4.3 A), allows users to add basic text and multimedia similar to the large panel, but multimedia will be confined to the width of the panel.

We used the side bar for written directions, narrative text, and supporting photos and videos. We also embedded a Google Form for each site with that site's assigned questions for students to complete and submit as they worked through the VFT site.

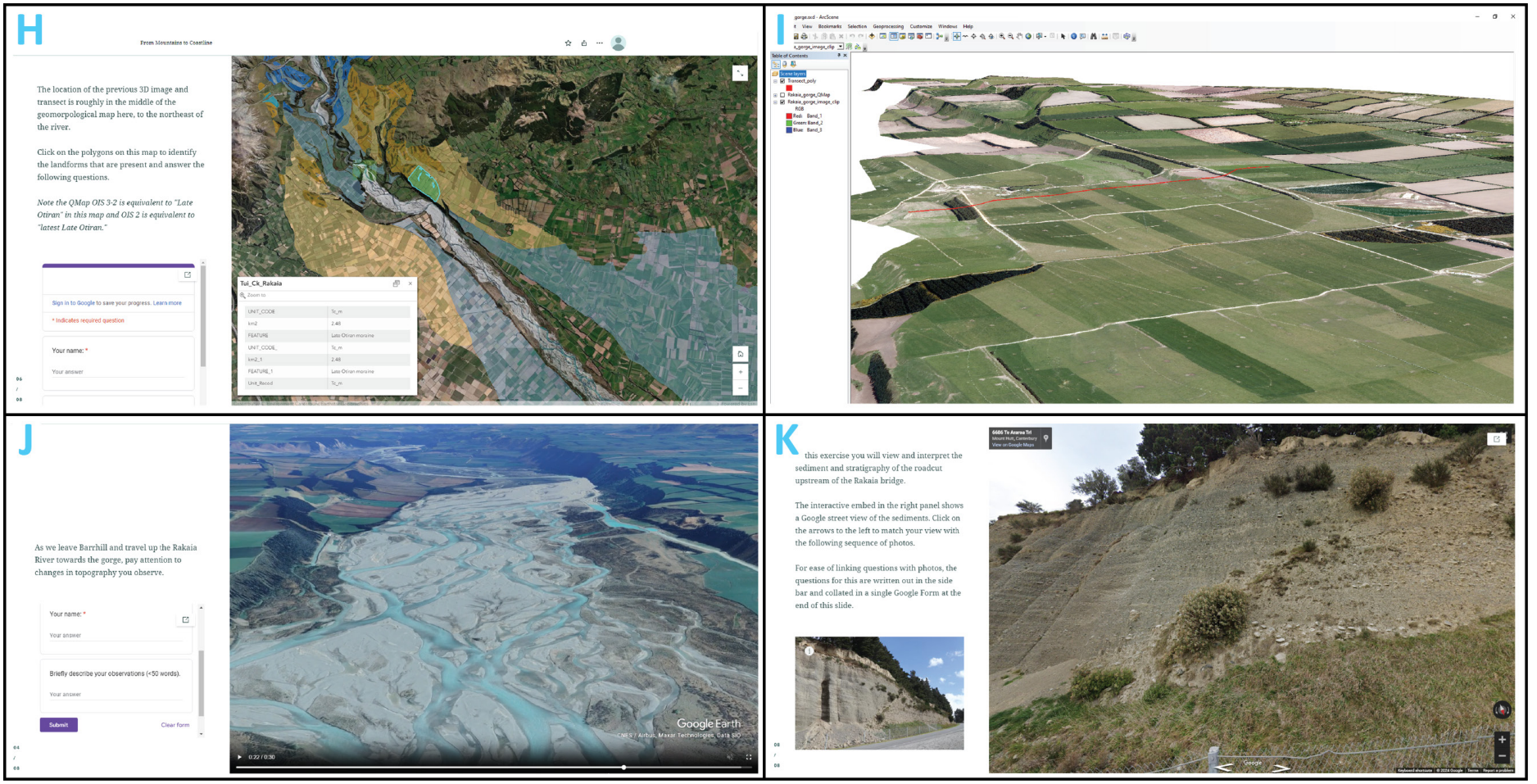

Figure 4.5 **Examples of multimedia used in the media panel. H) Web map of the geomorphology of the upper Rakaia River. Students can click on polygons in the map to bring up information about the landforms. I) The 3D model of the Rakaia River terrace site in ArcScene Desktop. The imagery raster, transect, and soil and geology shapefiles are draped over a digital elevation model of the site. In StoryMaps, students could turn the layers on and off and click on them in the model to bring up information about them, much like the map shown in *H*. J) Google Earth Studio animation. The embedded video takes students from Barrhill to the terraces in *I*. K) Google Street view at the Rakaia Gorge. Students can click on the arrows at the bottom of the panel to move up and down the road cut.**

Map action

Now a subset of broader "*media actions"*, the original *map action* (Figure 4.4 E) adds a button to the side bar that readers click to complete a pre-set map interaction. We added map actions to zoom into or out of field sites or to pan between sites to transport readers from one site to the next.

Google Forms

The examiner and I tried to keep all the assignment questions within the VFT so students did not need to switch between files on their computers while working through the trip. Although StoryMaps now supports adding code within a StoryMap that can be used for self-assessment, this feature was not available in 2021. Instead, we embedded a Google Form with field trip questions into the side bar of each site (Figure 4.4 F).

Express maps

Express maps are simple maps users can quickly create directly in the map builder in StoryMaps. Users choose what basemap to display, zoom to the area they want the map to focus on, and then populate the map with simple annotations such as points, lines, polygons, and text.

I added express maps to the Kaitōrete Spit sites to add reference points and photos of the landscape to the places we had taken the photos from (Figure 4.3 C).

Web maps

The StoryMaps map adder also allows users to add any maps they have published to their ArcGIS Online accounts, as well as other maps shared within their organisation or publicly published. Unlike Express maps, these maps are not limited to displaying simple annotations; the GIS data and layers in the original map will display in the Story.

The examiner created a map of simplified geomorphology of the upper Rakaia terrace surfaces and terminal moraines using ArcMap (Figure 4.5 H). He published this to his ArcGIS Online account and I added the map to our Story.

Web scenes

ArcGIS web scenes are interactive maps that display geographic information in a 3D modelled environment. They are made from a combination of *ground*, the modelled elevation terrain, a *basemap*, providing a variety of map display options, whether

cartographic or satellite imagery composites, and *layers*, geospatial data which can be 3D features or 2D layers draped over the elevation model. Users can create them either in ArcGIS Pro or the web-based Scene Viewer.

My computer and internet connectivity was too slow for me to use the Arc desktop apps at home or render data layers beyond basemap imagery online, so I could not add any data points or layers to web scenes. Instead, to emulate the feelings of being immersed in the field as much as feasibly possible, I made a scene using just the Terrain 3D ground model in Scene Viewer with slides showing the landscape at the sites moving from birds-eye view to overhead oblique angles to near ground-level views (Figure 4.4 D). These maps were interactive so that students could click into the map and drag to change their viewing angle, location, and distance to the ground to make observations about the surrounding landscape.

CityEngine scenes

To add higher-resolution 3D models of the field sites than could be accomplished with my use of web scenes, the examiner created two models of the Rakaia River in ArcScene. He exported them as 3D web scene files, added these to ArcGIS Online where I could take them and add them to the Story. Students could interact with the models to zoom in and out, change the angle of view, and turn on and off additional GIS layers such as surficial geology, soil type, and lines denoting topographic cross-sections referenced in the narrative side bar.

CityEngine Web Viewer, the application the web scenes worked within, was discontinued in 2023. As a result, the two 3D models of the Rakaia River are no longer functional in the StoryMap. The model shown in Figure 4.5 (I) is from the desktop application ArcScene instead of directly from the field site in the StoryMap. In the future, the examiner or I will re-make the models in ArcGIS Pro and export them as a web scene to re-add them to the StoryMap.

Google Street View

The media pane in StoryMaps allows users to embed links to external files and applications. One of our field trip sites was a road-side exposure of the Rakaia Gorge, which had 360° imagery in Google Street View (Figure 4.5 K). I copied the embed code of the location in Street View and add it to the StoryMap. This became an interactive media panel where students could click arrow buttons to move up and down the road cut and observe changes in the sediment.

Google Earth Studio

Earth Studio is a web-based application for creating animations using Google Earth imagery. Users can navigate within the globe in Earth Studio to the view they wish to capture, set a keyframe, then move to the next view and set a second keyframe. The tool automatically creates a smooth transition between the two keyframes as part of the animation process.

I made an animation that travelled up the middle of the Rakaia River, setting enough keyframes to ensure a smooth and slow transportation upstream (Figure 4.5 J). We directed students to observe changes in topography as the video transported them upstream.

4.6 VFT logistics: Running the VFT

4.6.1 Development and Delivery

The examiner and I developed the VFT over three weeks beginning August 20, 2021. We first designed the field sites in an unpublished copy of the StoryMap, where we would proof each other's work before I copied complete sites into the "live" StoryMap. Once the first three stops went live, the examiner assigned the VFT to the class. I posted announcements to the SOSC223 Moodle page when we added additional sites to the VFT. Students could access the initial stops from August 31st and gained access to later sites as we updated the StoryMap.

To help answer questions and troubleshoot issues, we ran live drop-in tutorials twice a week over Zoom. We used these video calls to answer questions, clarify instructions, add missing context, and note down problems with the VFT to fix afterwards. Attendance was voluntary and most sessions had only 1-3 students attend - less than a third of the class. We also welcomed students to email us questions or request additional Zoom meetings - five students sent questions through email.

4.6.2 The assessment (and troubles with Google Forms)

Each VFT site contained a list of assessed questions on a Google Form embedded in the narrative side panel. Students were instructed to complete and submit their answers within the forms for marks and feedback. Most did this without technical issue, but two students with poor internet connectivity lost their responses upon clicking "submit". After we learned of this issue, I compiled the questions into a Word document and disseminated it to the class for students to use instead of Google Forms if they wished. The examiner extended the due date by one week to give the affected students time to rewrite their responses.

4.6.3 Scaling marks

The class overwhelmingly performed better on the Kaitōrete assignment questions than the Rakaia River. The examiner and I chose to weight the class's marks in favour of the Kaitōrete half of the assignment, which more closely aligned the grade distribution to the distribution for the equivalent assignment in previous years. I discuss possible reasons for the disparity in grades between the two sections of the VFT in Chapter 5.

4.6.4 Disseminating marks and feedback

Once students submitted their responses I collated the Google Forms submissions into individual Word documents. The examiner and I marked the assignments and I wrote feedback in each students' document. I individually emailed each student their graded document for them to review their marks and feedback. We informed the class they could email us or request a private meeting if they had follow-up questions. At this point in the semester we had just gotten out of lockdown and there was widespread uncertainty about how we were to deliver the rest of the semester's teaching (i.e., what was to be in-person and what was to be online). Instead of devoting limited classroom time to a formal debrief of the trip, as is good field trip practice, we focussed our remaining time to delivering in-person laboratories with online equivalents and planning and preparing the class for the final, in-person field trip.

Chapter 5

Results and Discussion

This chapter responds to the 3 research questions guiding this study to assess our experiences with the SOSC223 VFT.

RQ1. What are student and instructor perceptions of the SOSC223 VFT?

RQ2. What are the strengths and weaknesses of the SOSC223 VFT?

RQ3. How does the SOSC223 VFT compare to TFTs in tertiary earth science education?

I begin by discussing RQ1 in section 5.1. I first describe the examiner and my experience developing the VFT, followed by our attitudes towards it as an educational experience. I then focus on students' experience with the VFT, starting with their attitudes going into the VFT, how they felt afterwards, and end by analysing what factors influenced students' learning and enjoyment of the VFT.

In section 5.2 responding to RQ2, I shift focus from the research participants onto the VFT. I reframe the factors that affected student and instructor experiences with the VFT to evaluate the strengths and weaknesses of the trip.

Section 5.3 aligns to RQ3 and builds upon the challenges and affordances of a VFT identified in 5.2 by looking at how they relate to traditional, in-person field trips in the earth sciences.

In Section 5.4 I discuss the examiner and my future intentions for the SOSC223 VFT, informed by students' feedback, and in Section 5.5 I conclude the chapter by discussing a blended approach to incorporating virtual and traditional trips into curriculum design.

Analysis and discussion of the results

I present the data in this chapter in the form of key quotations representing themes that are responsive to the research questions. Section 5.1 portrays individual experiences with the VFT, and so I include near-verbatim excerpts of interview transcripts to maintain the essence of each participant's voice, with only minor edits for flow and clarity. In sections 5.2, 5.3, and 5.4, discussing the strengths and weaknesses of the VFT, comparing it to TFTs, and discussing our future plans to develop the VFT, I remove repeated words, non-essential hesitations, and further edit for clarity. Spaced ellipses ('. . .') indicate an omission and words in square

brackets ('[ ]') indicate words not part of the original quotation. To protect student anonymity I refer to participants as "Student 1, Student 2," etc., and use the gender-neutral pronoun "they."

I follow each grouping of quotes with textual analysis. The brief analytic discussion following key quotes in section 5.1 is further developed when responding to RQs 2 and 3 in sections 5.2 and 5.3. In sections 5.2 and 5.3, textual analysis includes references to literature on VFTs, earth science field trips, and theories of learning as applicable, in order to discuss the results within the wider context of field trip education in the earth sciences.

5.1 Research question 1: What are student and instructor perceptions of the SOSC223 VFT?

In the following two sections I describe the examiner and my experience creating the VFT, including what we felt at the time, what impacted our experience, and our general opinions on the success of the VFT. I structured these sections as narrative flow punctuated with supporting excerpts from my interview with the course examiner, my self-interview, and my research notes from when I was working on the VFT.

After describing the instructors' experience and perceptions of the VFT, I discuss students' experience. I begin in 5.1.3 by analysing the pre-existing perceptions and expectations students held towards the VFT. This transitions to their overall attitude about the VFT after their participation.

Part of understanding students' experience was determining what students recalled learning, including what they enjoyed or were frustrated by and what factors enabled or hindered their enjoyment and learning. Section 5.1.4 covers students' self-reported learning and 5.1.5 analyses the factors that affected their learning and overall experience with the trip.

5.1.1 Instructor experience creating the VFT

The examiner and my experience creating the VFT was ambivalent. Although we both thought that the VFT itself was "not half bad" (Examiner) given the circumstances, our overall frustrations reflected the constraints of lockdown. We were negatively affected by poor work-from-home set ups, limited resources, and technical issues, and fatigue and stress

marked our experiences. The examiner talked about the discomfort of being confined to working on a single small screen:

> The thing was, being at home and doing it all from essentially that screen [*points to small monitor*]. That was… really unpleasant. Not, not a nice experience. And my overall feeling if I have to think about StoryMaps and developing it, I have the sense of claustrophobia. . . . I was in this very confining world. (Examiner)

We were stuck alone in our home spaces with only the equipment and materials we already had access to. It was unpleasant and physically, visually, and socially limiting. Months after we finished the VFT, the examiner still felt a sense of claustrophobia, of being confined and trapped, when he thought about his experience. I was similarly working off a single screen and I had no home internet and hot-spotted data off my phone to connect my laptop to Wi-Fi. This was slow and I was often unable to use ArcGIS to its full functionality.

My research journaling during lockdown was almost entirely fatalistic expletives about my frustration at my computer and internet not working, panic about how to change my research plan, and feeling that we were letting students down. In one particularly unprofessional and expletive-laden rant from the start of lockdown, I reflect on the stress and resentment I felt towards emergency remote teaching and needing to rethink my research design. I did not think I had room to consider research while simultaneously creating new teaching resources and trying to support students as best as possible while in lockdown. I thought that any VFT we made would be bad because “things thrown together in a week are not great generally, especially when you can’t go out to take good photos of sites” (Research notes, 19 Aug 2021). Although emergency remote teaching was an expected part of teaching through 2020 and 2021, it was difficult and everyone was dealing with the stress and uncertainty of Covid and isolation. Much of my initial negative attitude towards the VFT came from stress and pressures related to teaching and studying during lockdown, not from the VFT itself.

After I started to develop exercises and add materials to the StoryMap, I began to enjoy the puzzle of considering how to design digital sites to allow students to interact with and observe key parts of the landscape with the limited resources we had. I wrote:

> I'm doing okay here, other than running out of fast internet-data for the next week and a half. It's frustrating I can't use Arc [desktop software], but [the lecturer's] photos are good quality and I can add them to dots on the quick maps which should help students see changes along the beach. (Research notes, late-Aug 2021)

I wanted to include more spatial data into the Kaitōrete sites but could not with my limited setup. Instead, I considered how to best include what resources I *could* access to guide and enable students to observe features in the landscape. I relied on the examiner to make GIS resources, though he also had issues getting ArcGIS programs to do what he wanted. He recalled his irritation with ArcScene in particular:

> It wouldn't drape properly and to make it work, I had to have this huge offset between the draped layer and the actual ground surface. (Examiner)

Getting ArcScene working and correctly exported to web scene was frustrating for us both. The examiner had to edit layers in weird ways so they would display without being obscured by topography. I'd add his exported files to the StoryMap and check they worked correctly. They often did not, so I would read Esri support blogs for potential solutions and send suggestions to the examiner to test. This back and forth was time-consuming and could be disheartening. The examiner reflected:

> I lent on you a lot to actually… enact the, the things I was trying to achieve. I was relying on your skills so it was a little – I was a little frustrated that I couldn't do it all myself. But anyway it worked… it worked well as a team, but I know it was very hard on you too. (Examiner)

He was frustrated he could not troubleshoot issues with the VFT without putting additional pressure on me. I remember being similarly annoyed that I could not fix the files on my own once I found a solution. However, our division of labour benefitted us. The examiner had stronger content knowledge and access to and skill with ArcGIS so it made sense for him to focus on creating GIS models and exercises, and I was more familiar with StoryMaps so could more easily put the VFT together and fill in with content and resources as I could.

Though we both found it difficult to be so reliant on the other's skills and capabilities, our collaboration made the VFT possible. Even working together, creating the VFT was time-intensive and fatiguing. After 2 weeks of straight work, I wrote:

> Well gosh this thing is taking literally forever. We're now uploading it piecemeal… Just gotta finish up half of field trip 1 [Kaitōrete] for tomorrow and then the second half for Thursday or Friday. Next week hopefully we can get field trip 2 [Rakaia] up in one go. (Research notes, Aug 30 2021)

It was taking us so long to finish sites that we started releasing parts of the trip to the students before we finished drafting all of it. In his interview, the examiner exclaimed that

the VFT involved “a lot of time - and resources!” and by the end of the trip we were fatigued. We dropped the last site to the Bayfield moraines because we “ran out of energy and time” (Examiner) and did not have any good photos of the moraines. However, despite our difficulty and frustrations putting together the StoryMap, we did successfully deliver a VFT.

5.1.2 Instructor attitudes towards the VFT

My initial attitude towards the VFT was informed by the examiner and my adverse experience developing it and our ongoing technical issues. I felt pessimistic towards what we were able to create, knowing that we could have done better given the time and resources. In my self-interview I recalled:

> The maps didn't work very well. Even though you could like drag… Like, move yourself around and find the different resources that we added to the maps with poor internet connection, not everything loaded or it would freeze or it would just be painfully slow. And some of the things were just too hard or unclear… [from] the lack of time we had to really make something super coherent or like had the resources to do [so]. (Researcher, self-interview)

I thought our VFT was not scaffolded enough to be a good learning tool and that the malfunction of our interactive media would make it impossible for students to engage with it. However, students surprised me:

> [The VFT] was frustrating for me and it appeared to be frustrating for… for the students - both some of the content and the like, the virtual field trip itself, but also being in lockdown, not being able to go on the two field trips that we wanted to be able to go on… Like, despite the frustrations of that, students seemed to engage with a lot of… I don't know, “dignity” is not the right word. Earnestness? (Researcher, self-interview)

I viewed our ad-hoc VFT as a lesser experience compared to our typical in-person trips that I was afraid that the class would only half-heartedly attend the trip. This fear was misplaced and most of the class put effort and care into the trip.

The examiner felt similarly about students' engagement:

> I was pleasantly surprised, especially as I was getting the fatigue of actually doing it, thinking, “Oh well, the students are, you know, are engaging with it.” . . . Overall, I was gratified that the students gave it a go – and, and I thought they were very generous in the sense that they understood what we were trying to do in the circumstances and . . . cut us some slack. (Examiner)

We were gratified by the work students put into the exercises and the grace they extended us while we continued to upload sites, clarified instructions, and fixed bugs. Indeed, students' consideration and insight became a highlight of my interviews with them.

The examiner's final attitude towards the trip was that he did not “think it was as good as the real field trip. It was better in some ways, but worse in more ways.” but that nevertheless it was “not half bad, but it's really hard” (Examiner). I reflected that it was “good given the circumstances” and “could have been really neat had all the maps loaded better” (Research notes, Sept 2021). I will discuss the areas where the VFT succeeded and struggled in detail when I address RQ2 later in this chapter.

5.1.3 Student attitudes towards the VFT

Attitudes before the VFT

Overall, students' experience with and attitude towards the VFT was more positive than I anticipated. Initially, students were disappointed that the face-to-face trips were cancelled. When asked about how they felt about the face-to-face trips being cancelled, Students 1 and 5 replied:

> It was just annoying. Yeah it was annoying. Cause I do enjoy that field trip time. Especially with this class. I feel like it’s a class where the application of what you learn on field trips is really important. Especially with the case studies and stuff. So it was a little bit frustrating not being able to stand there in front of what we’re going to be learning or tested on and talk to you guys about it. (Student 1)

> Ah! Pretty annoyed, to be honest. But, again, it's not much we could do about that, just 'cause the restrictions, so… yeah. Just sort of, I think at this point I, I was, at the time I was sort of half like, Oh well, there's a 50/50 chance something is going to happen with Covid, which means it might not happen. So I was sort of expecting it, but yeah, I was disappointed just because, as I said, I do enjoy the practical field trips. (Student 5)

Although Student 5 anticipated that we might got into lockdown with the rise of Covid cases, both were annoyed and frustrated to lose out on a practical experience. They enjoy field trips and Student 1 shows here that they recognise the relevance of field experiences to the course. They value the embodied experience where they're physically standing in front of what they're to learn about, and the ability to have two-way dialogue about the landscape with “you guys” - us instructors.

The three other students similarly did not want to miss practical experiences, though they tempered their frustration with their feelings towards the wider context:

> It was, at the same time, relieving and kind of upsetting just 'cause, relieving because all the other things that were going on at the time. Upsetting, because obviously you kind of want to take advantage of all the experiences you can when you're doing the courses. (Student 4)

> There's pros and cons of both [the TFT and VFT] I guess, but it meant um. It would have been good to go and see it. And then I think, for me, I probably would have had a better understanding in a way, 'cause when I sort of go and see something first hand, it always sticks with me. Whereas on a computer screen, it doesn't really stick with me as well. (Student 3)

> I wasn't too sure about it [losing the in-person trips], but when you did the, when you announced that we're gonna do the virtual ones that sort of made me feel a bit better. So you actually get to put some of that into practical aspect. (Student 2)

Student 4 was relieved to have the certainty of not having to attend, or deal with rescheduling the TFTs. There was a lot of uncertainty going into this semester about what would happen in the country with Covid and the vaccine rollout had just begun; very few people under 50 were eligible to be vaccinated when we went into lockdown. Still, Student 4 expresses a desire to make the most of the different learning experiences provided for them at university and was upset to lose two such experiences. Student 2 was unsure how to feel, though would have felt more negatively were we to not run a virtual trip. They were relieved to not fully lose an opportunity to practically apply their knowledge or gain geographic context for what they'd learnt in lecture. Student 3 also immediately considers the VFT, and feels that both TFT and VFTs have “pros and cons”. They would have preferred to go “see” the field sites and link that seeing, and the implied embodiment of being there to “see it”, with deeper, better learning.

Student 3 uses the phrase “pros and cons” throughout their interview to compare the virtual and in-person trips and frequently acknowledges ways the VFT helped them learn, despite also considering themself “old-fashioned”, lacking computer skills, and disliking “looking at screens all day”. Going into the VFT they were sceptical that it could be an effective learning tool, saying:

> I'd never done a virtual [trip] before, so I’d only been on a real one, so I was a bit sceptical because, um yeah I just sort of, as I said, I'm not the best on the computer. (Student 3)

None of the students had previously attended a VFT, and just as this led to Student 3's wariness towards it, Student 2 did not initially feel it could be good and wondered how we would structure it to include visual information and "explain what's happening at the certain spots" (Student 2). Nevertheless they were receptive to the idea of a virtual trip and approached it with an "open mind". This uncertainty coupled with openness to the experience is mirrored in Student's 5 response:

> Thinking back, I wasn't exactly sure what to expect to be honest. Um, 'cause I think before that I hadn't really had a virtual field trip. Yeah, from memory, previous ones that got cancelled, it was more just doing like smaller exercises and stuff. So it wasn't like a, um what you guys had created, so I wasn't too sure what to expect to be honest, but I think my one expectation going into it was that just 'cause you know we hadn't been able to go and things like that, was that we would be given a bit of background knowledge for each question. Which there was, so that was really good. (Student 5)

They did not know what to expect from the VFT but did trust that we would provide students with context to answer the accompanying assignment, and, at least for this student, that expectation was met.

In contrast to the misgivings of Students 2, 3 and 5, Student 4 was very optimistic towards the VFT from the beginning. They thought it would be an effective replacement for the traditional trips and also had this to say:

> I just thought that it would be pretty cool to see how they would, um, sort of interpret a virtual field trip. So like, I was thinking like videos and photos and stuff and questions and that and… Um, yeah. That it would be pretty cool. (Student 4)

They expected the trip to contain a lot of visual resources to accompany the questions and that had a lot trust in our - my and the examiner's - ability to synthesise the content of the original trips into something that would be useful and cool.

Student 1 on the other hand was not so optimistic:

> I was honestly pretty pessimistic about it, going into it. I understand that it's like we're um obviously, I appreciate that fact that we're doing the best with the cards that we're dealt given Covid and given all the circumstances with the weather and that kind of thing, but I was like kinda a bit like mmm, I don't know, yeah, relatively pessimistic attitude going into it to be honest. (Student 1)

They were considerate of the wider context and that our options at the time were to cancel the field trips outright or try and convert them into something online, but did not anticipate that a virtual trip could do the experience of an in-person trip any sort of justice.

Attitudes after attending the VFT

After their experience with the VFT, Student 1 felt less negatively towards it, reporting to feel truly neutral about the VFT as a learning experience:

> If I just score it out of 10, I'd give it probably 5 out of 10, like straight down the middle. Wasn't good, wasn't terrible. Definitely helped given the circumstance that we couldn't be there but also would definitely have rather been there in person. So, it did good and it helped my understanding but I don't think it was, definitely wasn't as effective a learning tool as an actual field trip would have been.

Despite their misgivings and the overall stress of studying from home during lockdown, Student 1 found they learned from the VFT. However, they strongly feel they would have learnt more from being there in person and able to easily ask us questions in the landscape. This was a common refrain throughout every interview; students would have preferred a TFT had that been possible, or thought the VFT would have been easier if we could have run it in-person. As students 5 and 4 stated:

> I didn't necessarily dislike it, I just would have preferred to be in person. But again, wasn't much we could do about that. (Student 5)

> It was quite difficult. And I felt like it would have been a lot easier if it was in person. (Student 4)

This is also a common refrain throughout the literature on VFTs. For instance, Pugsley et al. (2022) examined outcomes of two replacement VFTs they held due to Covid. One theme from student evaluations was that the VFTs were "better than [students] had anticipated" (p. 243), and though student reflection and survey results were generally positive towards the effectiveness of the VFT, many would have preferred a TFT. And, though Seifan et al. (2019) found that measured learning gains were equivalent between a comparable VFT and TFT, student Likert responses favoured TFTs; given the choice to attend only one, students would choose a TFT.

Students valued attending field trips. Thus far in their interviews, this emerged as liking and learning from the embodiment of seeing the landscape and physically being there, and from the ease of asking questions in the field. With these both limited by the nature of our VFT,

students struggled with the exercises. Yet everyone still reported that even with its flaws, the VFT was an overall good learning experience:

> But I feel like it was a really good, um what's the word? Really good… replacement of the actual field trips. I think it was a good substitute. That's the word. For an actual field trip because it still got all the information across and you still get to see the sites even though you're not there. (Student 4)

> So I think overall it was very cool getting to have especially those interactive bits and being able to move the screen and actually look at, oh okay, so this is here and you know, comparing things. I think that was really good. It was just those small little technical glitches which were a bit annoying at times, but yeah. Again, couldn't really do much about that, so. (Student 5)

> I liked the experience, it was just, maybe it could have been a bit more clear and then it's a good, good thing I think a good way if you can't do the field trip or they don't want to go to the field trip. (Student 2)

> But um, after, it was actually not too bad, once you get past all the technological difficulties. And I reckon, if it's like laid out quite well and like really easy to use and navigate, then, I can definitely see advantages of it. . . . Overall it was quite good because I think I spent a lot of time on it, which meant that I understood it pretty well, by the end of it. (Student 3)

From students' accounts, the VFT appeared to have successfully led them to develop general knowledge of the content they visited. Student 4 reflects that the VFT got the information across that it needed to, and found at least some contextualisation, a mini-embodiment, through being able to see photos and imagery of the landscape. Student 2's response was more subdued. They liked the trip and thought it was a good replacement, but was upfront about finding parts of this VFT unclear. Clarity and technical issues are problems I'll discuss more later on, but even in the same breath of acknowledging the issues of the trip, the students recognised some potential of VFTs. Unexpectedly, this is best described by Student 3, who does not enjoy excessive screen time and had one of the most difficult times using StoryMap due to their poor internet connection. They appeared almost surprised to have found the VFT "not too bad" and even "overall […] quite good". They were able to spend as much time as they wanted on the VFT and the flexibility and permanency of the resource helped them learn, leading them to see the advantages a well-designed field trip could provide. Student 5's response suggests that interactivity and the ability to quickly visually compare different locations digitally may be some additional benefits of the VFT.

5.1.4 Learning outcomes, or what students did and did not recall

In this section I explore what students report to learn and remember about the content and learning outcomes of the trip. As I discuss in greater detail in Chapter 4, the VFT was created in two sections. The first part, to Kaitōrete Spit on the Canterbury Coast, replaced a half-day trip to the same location and was intended to teach students about the developmental history of the area, the processes and landforms present, and relationships between process and landform shape and behaviour. The second section of the VFT, to sites along the Rakaia River on the Canterbury Plains, replaced a day-long trip that focusses on the influence of the Quaternary climate cycle on the evolution of the Canterbury Plains and landforms and processes active there.

Students' overall view was that the VFT helped them learn, however, there are clear differences in what students remembered about the two sections of the trip. Students almost unanimously put greater importance on the content of the Kaitōrete Spit section and most frequently recalled specific exercises from this section.

> The main takeaways were… it was a while ago now actually. [laughs]. Yeah, just mainly took on the Kaitōrete Spit sort of stuff to be honest. Just the process and landform stuff there and yeah... (Student 1)

> For the Birdlings Flat, I feel like the creation of it and how the sediment would get there and how it was formed was a big thing. (Student 4)

> Just like the, I think the thing that I really remember most is the formation of like the longshore drift, the swash, and like all that stuff I remember that quite well. (Student 2)

> I remember quite a lot about in terms of how things were formed, so like linking back to that slip question, ah, sorry, ah, uh yeah, the split [spit]. I forget the name of it. But looking at you know how that was formed and looking at also how the waves affected formation of those and like the water flow and things like that. (Student 5)

> Yeah, well there was the, um, like the longshore drift down Kaitōrete, that was like. We'd done a lot of that. And then sort of that was a real life application so there was some of that. And then I found the glaciers, but they were all sort of, they all helped in a way. As opposed to something, for example, we did a bit on volcanoes. This, I still wouldn't clearly understand that as much as I would like the coastal systems, or like the alulia [*sic*], the wind one from the Rakaia, if you know what I mean. Because, both the field trip, um, we spent so much time on those concepts, so you really understand those ones quite well.

> Which is good. As opposed to sort of ones that you can't, you didn't do, for example. Yeah. (Student 3)

The main learning outcomes of the Kaitōrete section were for students to understand the evolution of the spit/barrier system and the relationship between the processes occurring and the landforms present today. Without any prompting with content details, all five students mentioned learning about coastal processes like longshore drift or how wave energy and direction affects the shape of the beach and coastline.

Only Student 3 ever mentioned learning or enjoying any content from the Rakaia River section of the VFT. Some directly stated that they did not remember the Rakaia sites, even when directly prompted:

> Um, I don't remember much of that one, so I wouldn't be able to say, sorry. (Student 4)

> The [purpose of the] Birdlings Flat one was to look at the formation of the – of the Lake Ellesmere and that stuff, and the Rakaia was the river… I'm sorry I can't really remember the Rakaia one too well. (Student 2)

Otherwise, the lack of lasting memory of the Rakaia River exercises appeared in its absence. After outlining their key takeaways of the coastal trip, Student 4 stumbled and apologised for their poor memory:

> Um, I can't really remember anything else. Yeah… Was it, ah… No, sorry, my memory is horrible. (Student 4)

Despite their self-described horrible memory, Student 4 remembered much of the Kaitōrete section, suggesting their memory is not at fault for not recalling the Rakaia River content. This is similarly missing from Student 1's interpretation of the purpose of the field trips:

> The content was just like the process landform, um, relationship in both [the coastal and Rakaia River] scenarios. And then honestly… Ah, skill wise, there was the sort of like, the planning aspect, when it came to the Kaitōrete Spit, but like the questions that were sort of asking about the, how, what would you think would be the best way to keep the channel open, and that kind of thing. Because there were questions on that, so I think like that's the management aspect as well in terms of the skill front, just getting you thinking in that direction. (Student 1)

They clearly understood one of the main learning outcomes of these trips - to understand the relationship between Earth surface processes and landform formation and shape, and to begin to link process and landform to land and hazard management. The structure of the

Kaitōrete Spit section was intended to facilitate this understanding while also building student's observation and interpretive skills. What was missing from Student 1's description was the formation of the Canterbury Plains as influenced by the Quaternary climate cycle, the intended focus of the Rakaia trip, or any content specific to the Rakaia River sites.

Interestingly, Student 3 did recall details about both sections of the VFT. They stated that the VFT provided them with the repetition they need to learn and go on to mention the longshore drift of the Canterbury Bight, the "real life application" of that, referring to the exercise critiquing the groyne at Birdlings Flat, the Holocene loess site midway up the Rakaia River, the "glaciers", referring to the glacial outwash and terminal moraine map they reference liking earlier in the interview. They compared these field trip learnings to the unit on volcanoes, which is taught solely through lecture. This reply begins to hint at the context and reasons behind when and why students learned from, enjoyed, were frustrated by, or did not recall exercises in the VFT.

What students report to have learnt and remembered from the VFT matches how well they answered the VFT assignment questions. The class as a whole did much better on the Kaitōrete Spit exercises than the Rakaia River exercises, to the extent that we decided to weight their marks in favour of the Kaitōrete questions so that the class' grade distribution matched previous years' project marks. In the following section I explore the factors that affected students' experience with the VFT which help explain why students had inconsistent retention between the Rakaia and Kaitōrete sections of the VFT.

5.1.5 Factors affecting students' experience using and learning from the VFT

Students' interviews contained many data contextualising when and how they benefited from and were frustrated by the VFT. Students found it difficult to achieve *social connection* but were helped when they did, and were simultaneously challenged by the self-directed nature of the VFT while benefiting from its *flexibility*, which allowed them to work at their own pace. *Technical issues* adversely affected all but one student, and *context and clarity*, *personal interest*, and the *integration* of the VFT content into the overall course design appear to have aided students when these factors were present and frustrated and disengaged students in their absence.

Content alignment within SOSC223

The learning outcomes of the Kaitōrete Spit and Rakaia River field trip were unevenly supported in the laboratory content of SOSC223. A pre-lockdown laboratory session focussed on the evolution of Kaitōrete Spit. In the laboratory, students worked in teams to read and interpret data excerpts from published studies on the geomorphology and sedimentology of the area. They pieced together a rough timeline of the development of the spit/barrier system and the oscillations of Te Waihora | Lake Ellesmere between an open lagoon when the Waimakariri River flowed into the area and closed lake when the river avulsed away, allowing the spit to weld to Horomaka | Banks Peninsula and build out a prograding barrier. This was intended to prepare students for the field trip the week after lab.

In a normal year there is also a preparatory lab for the Canterbury Plains trip to the Rakaia River that directs students to think about differences in sea level, sediment supply, and river behaviour between the last glacial maximum and today's interglacial period. In 2021 we cancelled this lab to focus on creating the VFT, so students were only introduced to the Rakaia River content in lecture. This affected students' understanding of the two sections of the VFT. Student 2 shared that the lectures and lab helped them to understand the landscape, and thought there was a difference between background knowledge for the two sections of the VFT:

> Yeah, cause we had a bit more prior knowledge, so we felt a bit more confident answering the questions. (Student 2)

Their previous knowledge about Kaitōrete Spit helped them feel confident completing the Kaitōrete exercises compared to the Rakaia River. Student 1 shared the same conviction with Kaitōrete content:

> Yeah, I think also the… the spit we'd done like labs on it and stuff before as well, which definitely would have helped a lot like whereas the Rakaia was all kind of fresh. . . . So that knowledge that we had before the Kaitōrete Spit thing we sort of understood the processes that we were focusing on, talking about really helped, whereas the Rakaia River we hadn't really gone into it before that point. So I think it was yeah, probably just a matter of the knowledge that I already had in my head leading into it that made it a lot easier to get through or just easier to understand. (Student 1)

Our introductory laboratory built a foundation for the field trip such that Student 1 found it easier to understand and complete the exercises for the Kaitōrete Spit sites. Without the

same foundation for the Rakaia River, they were more hesitant in their approach to or understanding of Rakaia content.

Complementing how Students 1 and 2 related their in-class learning to being more certain of their VFT assignment responses, Student 5 discussed how instances when the VFT linked back to classroom materials helped them build self-assurance:

> Um, so again with the split [*sic*] question, being able to have the links to the lecture material was good because we got to basically look through again and say oh okay, yeah, this is how it's done, so we could double check our information. (Student 5)

Some of the diagrams we used in the VFT came from lecture slides. Student 5 noticed these links in the Kaitōrete content and liked being able to refer to their lecture notes to check their information.

The above responses indicate that the alignment of the VFT to the design of SOSC223 was more successful for the Kaitōrete Spit section than the Rakaia River. This resulted in students having more self-efficacy and confidence in their approach to the Kaitōrete exercises and added to the difficulty and frustration some students felt towards the Rakaia River questions.

Personal interest and connection

In addition to course alignment, students' interest in the VFT locations played a role in how engaged they were. Student 2 was more interested in the coast and Kaitōrete Spit than inland Canterbury Plains.

> It’s just like probably interest more, for me, like, what that I found a bit more interesting I put a bit more effort into. And that like, was the Birdlings Flat one. (Student 2)

At the start of their interview, Student 2 mentioned that their experiences surfing led them to develop an interest in water quality. It is possible that their greater interest in Kaitōrete Spit and coastal systems over the inland Rakaia River was due to their interest in surfing, although I did not think to ask during the interview. Whatever the cause of Student 2’s increase interest in that location, they state that their personal interest led them to put more effort into the Kaitōrete Spit content.

In a similar vein, Student 3 has background in farming and felt more personal connection to learning about the soils on the Canterbury Plains.

> Yeah, I remember the, the second one, with the soils on the the um, Rakaia, like, terraces. I really enjoyed that one. I just found that interesting, but that's probably just like personal preference. (Student 3)

They enjoyed learning about the impact of loess deposition on soil development on the high terraces next to the river more than they enjoyed any of the Kaitōrete Spit content.

Previous familiarity with the locations also influenced students' interest in the VFT, at least for Student 1, who had visited Kaitōrete Spit on multiple past occasions:

> Personally it was probably the Kaitōrete Spit ones because I've been on field trips there in the past and I feel like the fact that I had been there before, even just like been out there to hang out with my friends as stuff sorta helped a little bit. Yeah. Whereas the Rakaia one I hadn't been out there at all before so it was a bit confusing.

Their past experiences at Kaitōrete Spit connected them to the location and helped them engage with and understand the VFT content. Without the same personal connection to Rakaia, Student 1 was more confused by the Rakaia River exercises.

Technical issues

Internet connectivity was the largest technical issue faced by students. Student 5 outlines the impact this had on their general learning during lockdown:

> The other downside to learning online, especially from home, is lack of internet. Unfortunately for ours. So it can be a bit difficult trying to do all this online learning, but not necessarily have a good internet connection, which means I can be watching a lecture and then suddenly it will cut out. So there's that downside to it, but there's always the thing of you can download the videos after and then watch them offline if you need to. So yeah. (Student 5)

Unfortunately for those with poor internet, StoryMaps required a stable internet connection. Glitches where maps lagged or did not fully load frustrated nearly everyone:

> The GIS, that was quite good, but I've sort of found a problem like it was like a bit glitchy and like took a while for it to catch up on the computers. . . . when you tried to get going it got a bit frustrating. (Student 2)

> I found the [Kaitōrete Spit] maps not the best for me to use. I'd click on to it and then it'd do something and that got me frustrated. [Laughs]. But yeah. Probably just, yeah, just that like I had a few issues with it, but, um, other people might not have. (Student 3)

> I get frustrated very easily when things don't work. So. Yeah, I was yeah, sort of just. Yeah, I found something frustrating… It just, yeah, didn't help, but yeah. (Student 3)

> It was just those small little technical glitches which were a bit annoying at times, but yeah. Again, couldn't really do much about that so. (Student 5)

For most, the malfunction of the VFT involved StoryMaps lagging in response to students scrolling and clicking into the maps and GIS layers. Student 2 liked the concept of the GIS, but found that its slowness to respond made it difficult to stay engaged with the VFT. This particularly affected their experience with the Rakaia River maps and GIS. Though annoyed, Student 5 appeared resigned to the trouble of map glitches. Most of the Kaitōrete maps did not load correctly for Student 3, which immensely frustrated them and did not help their learning or enjoyment of the material.

Student 4 did not elaborate on any frustrations they may have felt due to technical issues, but shared that in addition to bad Wi-Fi, their laptop died during lockdown and they lost access to the trip while it was away for repairs - something I did not know at the time.

> Well, my laptop kind of died on me, so I had to send it to the computer guy to revive it but, um, that was like a week at most and then Wi-Fi, it's just on and off at the university flats, so. (Student 4)

Student 1 had no connectivity issues.

The parts that did not work for students were surprisingly varied. Student 5 had issues throughout, where content would not load in one of the Kaitōrete maps or in the Rakaia GIS models:

> Well we did have that issue with, I forget which map it was, but it was one of the interactive ones where you can move it, um, and see, I think we had an issue with trying to find the location for a pit or something which was related to one of the questions, so we couldn't really answer it. Because that that bit wasn't working for us. And then I think I had one further along which was looking at… It was one of the big rivers and it had um, overlays of different colours on it, which would give you different information. But when I clicked on them, the information wouldn't come up. (Student 5)

They refer to "we" as them and Student 4, their friend and flatmate with whom they worked through parts of the trip. During the VFT, both students contacted me for help finding photos in the map at site 1, and the Rakaia GIS models did not consistently show them soil and geology information when they clicked on different layers.

Student 2 had issues with the Rakaia GIS models and directly stated that as a result, they did not put as much effort into those sites:

> And the Rakaia one had the GIS bit in as well which I found, well it made me a bit frustrated when it didn’t work and so didn't put enough effort into it. (Student 2)

Conversely, Student 3 had the largest trouble with the Kaitōrete maps and was able to use the Rakaia land surface models and GIS without the same frustrations.

> There [were] a few images [in the Kaitōrete maps] that I couldn't get onto for the start of. But then, I think somehow after like a week or something they managed to come up or something. But then, I don't know, I had a few problems with it, where it would freeze a lot. Um, also, and then. Well, I had the issue, um, I went back onto it and there was no answers there, but. Yeah, just little things like that. (Student 3)

Not all of those bugs resolved after a week and I emailed Student 3 screen shots of all the Kaitōrete sites and photos. Additionally, they discovered that Google Forms did not save their submitted question responses if their internet dropped mid-submission. Once they discovered this, I emailed everyone in the course a Word document with the assigned questions and student's individual answers submitted thus far. This issue affected Student 3 the most, but Students 4 and 5 found that one or two forms had not saved their responses. Losing work and thus needing to re-do the exercises was frustrating and disruptive for the affected students.

In addition to connectivity issues, students faced other technical difficulties relating to StoryMaps. Student 2 used a Mac, and found that StoryMaps did not load correctly on their web browser. Luckily, they were able to remotely access university computers that did load the VFT.

Technical issues were a detractor from students' VFT experience. Other than Student 1 who had a strong Wi-Fi connection, all students faced issues with internet connectivity resulting in StoryMaps lagging or not loading content and three lost some or all of their work when Google Forms did not save their submissions. This led to frustration and lost time and, at least in the case of Student 2, was one factor influencing how much effort students put into a given site. It is worth noting that Student 3, the only participant to prefer and remember the Rakaia River content over the Kaitōrete sites, was disproportionately affected by problems with the Kaitōrete maps.

Context and clarity

The clarity of different resources and the context they provided both positively and negatively affected students' experiences using the VFT. The written and visual resources in the StoryMap were intended to provide students an understanding of what the field sites looked like and provide enough information for students to synthesise into their growing understanding and interpretations of the individual sites within the wider landscape. Students generally liked the visual information provided by the maps and imagery and appreciated when the content imbedded into a VFT site was rich enough to be all they needed to answer the assigned questions. Students were negatively affected by sites missing information and broader context and confusing questions or instructions.

Positive influence

Students liked when the VFT provided lots of background and context for the site and assignment questions:

> Um, I think also the some of the questions had like a broader background of um information for the question, which was good. I think like, I can't remember the exact question that it was, but it sort of gave a little history about how it was formed, so it was good to have that knowledge in the background while thinking about how to answer the questions. (Student 5)

> There was one I can't quite remember. I think it might have been the Rakaia. And it had like a map of was it, ages of glaciers, and ah. Like it had, like it was an interactive map where you could click on certain areas and then it'd come up in a certain colour. . . . That one I found like that was really good I thought, for sort of like. The question, I remember there was a question in that section that that map really like, um, helped sorta answer that question. (Student 3)

Student 3 thought the Rakaia River glacial geomorphology map and related questions was the most engaging exercise. They were able to interact with the map and data layers to understand how the landforms related to each other, and used their interpretation within their question response. For Student 5, broader background given to contextualise some questions helped direct their thinking. They appreciated having additional context woven into the VFT and later elaborated with an example where we included a brief video about spit formation and longshore drift:

> I found [the video] quite helpful just because again with the visual learner being able to watch a video that's quite good for me because then, again, I sort of engaged with it more,

> but also I find it easier to link it to like the question being asked, so thinking, "oh, okay, so this is how it formed here, so how would that link to the formation of this question?" you know. Um, and things like that. So, I think you know having the video there was good . . . (Student 5)

The longshore drift video did not teach anything new to the class; we included it to refresh what students learnt in earlier lectures. Student 5 used the video to remind themself of the processes involved in spit formation to then relate these processes to the field trip site and answer the assigned question. Student 4 similarly appreciated when images and diagrams directly helped them to answer questions. When discussing their favourite questions, they shared:

> I liked the diagram ones where you had to explain the diagram or how it relates to the area that you were looking at. (Student 4)

They enjoyed questions that enabled them to interpret how information in diagrams related to the landscape.

Student 4 frequently referenced liking and learning from the visual resources. When I asked them what helped them to understand how the landscapes formed they replied "definitely the diagrams!" and appreciated that we used our own photos from past field trips:

> I liked how they included all the photos like, actual photos that they took and stuff like they'd, [one of the lecturers] took as well. So you could kind of see that they're up-to-date photos and not just ones off, like, a website or somewhere like that. (Student 4)

The lecturer's photos gave a real life context to the VFT sites that better connected Student 4 to the landscape than had we used stock imagery or images not directly connected to the field trip locations and content. Photos from past field trips added a sense of authenticity to the VFT, where demonstrating our connection to the field sites increased Student 4's engagement.

Student 3 likewise developed connection to the landscape by interacting with the maps and GIS:

> [The VFT's] laid out in the way that you could see the maps. You could like, ah, interact with it and like get your bearings, sort of. (Student 3)

They continued their earlier explanation of why they were most engaged by the glacial geomorphology map:

> It was really good to look at [the landscape] in that perspective. And that, I think, you, you wouldn't even be able to sort of do that on a normal field trip, obviously, so I think that was really beneficial because, yeah. That really helped for that one. . . . you could turn off certain layers and sort of look at one thing and then turn it back on. And there might have been another even that was like that; you could turn off certain things, and I think that was quite good. (Student 3)

The interactivity of the GIS maps allowed Student 3 to view the landscape from different distances and angles and control what spatial data was displayed. This enabled them to connect with the field site and understand where they 'stood' in the landscape and how the landforms related to each other. The visual data woven into the VFT provided students with context to engage them with the field sites. Without being physically in the landscape, students relied on the photos, diagrams, videos, maps, and GIS layers to connect them to the locations and help them understand the processes forming the landscapes and how this has changed through time. Though students missed being in-person, many highlighted instances the vicarious experience of the VFT helped them to visualise complex processes, sometimes in ways that were not possible on a traditional trip.

Negative influence

Unfortunately, visual resources were not always smoothly incorporated into the VFT and students' learning was negatively affected by confusing instructions, question wording, and missing information. The SOSC223 examiner and I developed the VFT as an emergency response to Covid lockdown and cancellation of the in-person trips to Kaitōrete Spit and the Rakaia River. We uploaded the trip in sections, where once we completed a site I would add it to the published StoryMap and email the class that a new site was available. We had limited time to create and revise sites and no opportunity to edit the VFT into a single polished experience. Student 2 reflected they were uncertain about the general instruction for the trip and wanted more clarity from the beginning:

> Maybe just like the direction of like how, we wanted it, you wanted it to be filled out like, how much time we had before that section is due? (Student 2)

Student 2's confusion is unsurprising; although we were upfront with students about the situation and modified sites and instructions on the fly, the quality of the VFT varied across sites and it lacked unified instructions. While they did not mention this in their interviews, Students 3, 4, and 5 emailed me separately to check when the assigned questions were due

before we had set a deadline, suggesting they were similarly confused. They also sought help to clarify what some of the questions meant, which was reflected in what students disliked about the VFT:

> I think just some of the, the way that the questions were stated. Yeah, just as I said earlier, the wording kind of gets me sometimes and confuses me, but yeah. (Student 4)

> I just I remember there was just questions that I sort of found were hard to answer, but… You get there in the end. (Student 3)

> I know I did have trouble with the wave calculation one. Um. But I think that was more, I just wasn't confident with how to answer the question. (Student 5)

The content of the trip was not always easily understandable and some of the questions confused students. Student 5 specifically mentions being unsure how to approach the wave calculation question, which I had cut from the VFT early on because it was unclear. Despite not being graded on that particular question, Student 5's confusion stuck with them. Students 3 and 4 mention that generally some questions were confusing or hard to answer.

Student 3 elaborated that their difficulty to answer these questions was due to a lack of supporting information in the VFT:

> I can't quite remember all the questions off the top of my head, but I just remember there were questions that I could answer very easily from the context and the text given and then there were ones that I found sort of, I couldn't get too much, um, from the text and dialogue to help answer that question. Which means I had to go, sort of research things. Which might not have been a bad thing, but, I just found, yeah there were certain questions that were like difficult to understand or – or difficult to answer based on the context. If you know what I mean? (Student 3)

They liked when the assignment questions were clear from the context provided by the VFT and had a hard time understanding or answering questions when there was not enough explanatory text or supporting data, diagrams, or visual resources. Although they acknowledge possible benefits from referencing external resources, they preferred having that scaffolding included within the VFT alone.

Student 2 was also frustrated when content in the VFT was missing context:

> Some of the just the photo ones were pretty, I don’t know, just hard to understand if like it wasn't labelled or something like that. . . . Yeah, some of them were quite hard to zoom in on. (Student 2)

In the unpublished StoryMap, the photos in the Kaitōrete map pins that Student 2 refers to were large and chosen to show details of the landforms at each site. Some included explanatory captions, but most were standalone photos. Upon publishing the StoryMap, the photos embedded in map pins compressed into thumbnails. As Student 2 stated, these were too small to observe detail, and without additional text, they had a hard time understanding what the photos intended to communicate.

Student 3 noted that the same Kaitōrete maps gave them trouble:

> When I clicked on the map like I wanted to see a certain part, but it wouldn't show that part that I want to see. So I found it hard sort of get my bearings and I, I just found that the map wasn't very clear, so it was hard to sort of, um, answer the question so it just took a long time to do that one. (Student 3)

They go on to note that the resolution of the Kaitōrete maps was too low to make close observations of the landscape without better accompanying photos. They had a difficult time situating themself in the landscape and were frustrated the maps would not show them what they wanted to see.

Another aspect of *missing context* was our failure to include adequate instruction on how to use the interactive tools in the VFT:

> There was one particular activity that was using some sort of GIS map, there was a question and it took you to like a different sort of map tool and I remember finding that real confusing and like a bit tricky to get through. (Student 1)

The GIS models used in the Rakaia River section showed 3-dimensional photographic imagery of the river and surrounding terraces with interactive layers displaying surface geology and soils. Students could click on layers in the legend to turn them on or off in the main map and then click on the displayed layer in the model for layer information to appear. Student 1 found this confusing and tricky to do without explicit instruction on how to use the tool. These are the same models that Students 2 and 5 mentioned did not work properly; perhaps their technical difficulty was exacerbated by inadequate instruction.

Social connection

Peer and instructor connection affected students' enjoyment and engagement with the VFT. Most participants suggested that they would have been less confused by the content and instructions with an instructor present to guide them in real time. Overall, students missed interacting with each other and with us instructors while working through the VFT:

> Probably the main annoying part was yeah just not the like having the discussion aspect as much between yourself and the lecturer and between yourself and other students. Like if the lecturer was explaining something, sometimes you got a classmate who understands it more than you and you're standing next to them and you can just quickly talk to them about it like "oh what did he mean by that?" and they'll explain it to you, where this was just all sorta like left to you which is a bit, definitely a bit trickier. So it was the interpersonal aspect which… sorta quite obvious, obviously [student laughs]. It probably makes good sense. (Student 1)

> I sort of found it a bit difficult to keep on task like 'cause I have all those distractions of your phone like computer, just like you go on random stuff on the internet. But like it's good if like we have like a zoom meeting or something like that 'cause it keeps you more entertained. As well. (Student 2)

> Just the time aspect. Maybe if we did like a Zoom class, or like a a computer class, where we could work on it together. Something like that. But if it's like a lock down, you can't really do class or anything. Like the [garbled] and ask questions. (Student 2)

Students would be able to ask quick questions and be more confident in their approach and answers if they had had an instructor present, whether through a video call or an in-person computer lab as suggested by Student 2. Student 1 highlighted the lack of social connection on the VFT as its main downside. In person, they could chat with their peers to make sure they understand something an instructor said but direct expert guidance from an instructor talking to the class in real time and easy peer support were lacking from the mainly self-directed VFT. Student 2 also wanted synchronous working sessions. They found that they struggled to maintain focus during lockdown, mentioning being easily distracted by their phone and the internet, and wanted the connection of a video class to help them engage with the trip, work as a group, and get their questions answered.

Students 3 and 4 agreed that they would have been helped by the impromptu clarifications and explanations we could provide in a synchronous setting:

> I can't quite remember, but it's the type of questions that like if somebody like yourself or a lecturer were there and you just had them there just to be able to clarify things, I think it would have helped me a lot. Because some of the things you think, "oh this sounds about right, but I'm not sure." Just having a bit of like clarity on that could help. (Student 3)

> It was quite difficult. And - and I felt like it would have been a lot easier if it was in person, but since it wasn't possible, yeah, I um, I did struggle with it a bit to get through all the

> questions, and since you didn't have someone there, you couldn't ask about like the wording of some questions. (Student 4)

Some of the questions that both students struggled to get through in the VFT would not have been as difficult had we been able to immediately assist them when they came to a confusing part. Instead, they had to email us and wait for a reply, or hold their questions to ask in one of the four synchronous tutorials we held on Zoom. Student 5 did the latter:

> And the other thing that was good was you guys running the Zoom [tutorials] so we could go and ask what we were confused on which was really helpful. Um, so 'cause we had a few questions where we were like we feel like it should be easy but we're just not understanding how it was, you know, how we should be answering the question, so being able to talk through it with you guys was really helpful. (Student 5)

They used the tutorials to check that they were on the right track with sections they were confused on and found our guidance helpful. Student 3 initially forgot that we had run Zoom tutorials, but later in their interview reflected that the tutorials were similarly useful. Although few students attended the voluntary tutorials, they appeared to have helped those who engaged with them. I will further discuss tutorial attendance and the shortcomings of how we structured the Zoom calls when further addressing the strengths and weaknesses of the VFT in research question 2.

Some students helped each other work through their questions and confusion instead of relying on the tutorials or emailing us for help. Students 4 and 5 and Students 1 and 2 both worked in pairs for many of the exercises. Student 5 only briefly mentions this in their interview, but Students 1 and 2 shared:

> It was a while back but I just remember flicking through step by step there was like it was honestly a while ago now wasn't it. It's a bit of a tricky one. I remember flicking through the maps and like cruising through and also using some of the virtual tools. Like there was a bit of GIS stuff in there. But yeah. Um, a lot of it was like honestly like talking to classmates and trying to figure out the answers to questions together sort of thing, like working through together. But yeah that was the kinda things that I can remember. . . . It was mainly me and [Student 2] probably actually, just talking to each other, yeah? (Student 1)

> Yeah, I worked on myself and a bit with [Student 1], if like we were stuck on a section. (Student 2)

At the beginning of this section, Student 1 stated that the biggest downside of the VFT was losing their connection to their instructor and peers that they have on TFTs. They managed to partially overcome this by talking and working with Student 2 to get through the exercises and help each other when they were stuck. Student 2 found this self-directed social presence helpful, but quickly agreed with me that it would have been easier for them if we had scheduled a set, structured class time to work through sites as a class. In this VFT, student's social connection with each other and us instructors relied on their self-efficacy. Students had to choose to attend the video tutorials to ask us questions live and choose to contact each other to work together online during lockdown. While this self-directedness appeared to challenge many in the class, the flexibility and repeatability of the VFT also aided in their learning.

Flexibility of the VFT

Everyone, including Student 2 who emphatically would have preferred more external structure, liked aspects of the autonomy and repeatability of the VFT. Most students appreciated that the flexibility of the field trip let them pace themselves:

> Mmmm, It's quite good, it was quite good how we could like sort of break it up into bite size pieces. And like sort of do like an hour of it here and two hours of it here and then come back to it. Whereas on a field trip it can be like you know, a full day of information being crammed into your head and by the time you get to the last part of the field trip it can just be like a bit, sort of like an overload of information. And it can get like quite tiring like, you know, it's always like the start of the field trip where that information seems to sink in but then by the time you've done a full day of going through things that's when everyone starts yawning and looking a bit tired and ready to go home sort of thing. So I think that was a good aspect of it, the fact that you could break it up a bit more than that full day of doing a field trip. (Student 1)

> Well, I like the fact that you could just sort of do it anytime and you could always come back to it and you could do a little bit and then have a break and then, sort of, come back refreshed. And you, you sort of got more clear understanding rather than doing it all at once, but yeah, so that's probably what I liked about the virtual field trip is that you could just do it sort of leisurely. And you could sort of, I don't know, spend time on it. And think about it a bit more. (Student 3)

> I liked how it was kind of like an assignment, how you could like add on to it each day or each time you went onto it, which was quite good and it took off some of the stress of like you have a specific time limit that we have to finish it. (Student 4)

> Being able to work through it at your own time was really good because you could, again, there was no stress on “oh, okay, I, um, I need to get it done in the time.” Well, we did have a time frame, but it was quite broad, so you didn't have to be rushing and you could go back, look at notes, do some research if you needed to, which was really good. (Student 5)

Student 1 compares their ability to break up the VFT to a TFT. They find TFTs can be tiring and overwhelming by the end of the trip when everyone is ready to go home. They liked being able to take breaks from the VFT to rest or do other work and come back to it later. Students 3, 4, and 5 also liked the leisurely pace of the VFT, where they could return to it refreshed. This allowed Student 3 to spend more time thinking about the content and felt they understood it better than had they gone through all at once.

The flexibility and broad timeframe to work on the VFT reduced Student 4 and 5's stress compared to something short where they would have to rush to complete it, which allowed Student 5 to revisit their notes and do external research to help complete the assignment. The flexibility of the VFT also let students repeat content; Students 3 and 5 reflected this helped them learn:

> From memory, I think I spent a reasonable amount of time on it. But for me, I generally spend more time on the project anyway just because I have to like, um, for me, learning is like a repetitive process, so quite often I’ll re read through the questions or I'll like read through all of them and then figure out, okay, which ones can I do first which I'm confident with and go back and look at the ones I'm less confident on or ask help (Student 5)

> Well, I found like overall it was quite good because I think I spent a lot of time on it, which meant that I understood it pretty well, by the end of it. And I think because I sort of went over it and over it and over it, the more times you go over it and repeat something, the more likely you are to sort of absorb that information which I think probably helped understand, sort of, major concepts in the course. Which then helps with the, sort of like, exam study and stuff like that, but also just understanding it, um, more. If you know what I mean? (Student 3)

The entire VFT was accessible to students regardless of where they were in the trip. Student 5 used this to guide their workflow, reading and re-reading questions to focus on ones they could easily answer and later research or get help on ones they were uncertain of. Student 3, thought that working through the trip multiple times led them to more deeply understand

the major concepts in SOSC223, which later helped them prepare for the final exam. Students 2 and 5 also used the VFT to revise for the final exam:

> I think it's good as a learning tool because you can go back and, well obviously not with that issue with the Google questions, but it would be good to have it as like a reference, especially when like studying for exams. You can go through and look at, “oh okay in this example that this is how I answered it.” Or, “this is what I learned from that question.” I think it's good to be able to go back and look at it. (Student 5)

> It was good to go back and refer back to like if you want to go back and be like “I can't really remember this bit” or you want to use it for study or something like that. (Student 2)

Students could review the field trip sites anytime they wanted to, which helped them refresh and remember what they learned on the VFT. Though Student 5 points out that the way we set up the question submissions using Google Forms did not let them see their question responses within the VFT itself. Instead, they had to open a separate Word document with their marked answers to cross-reference with the StoryMap webpage.

5.1.6 Summary

Students and instructors alike went into the VFT with little idea of how it would turn out. The examiner and I faced many challenges creating the StoryMap exercises and our frustrations working with inadequate resources during lockdown set a pall over our recollection of the trip and expectation for students' experience. Initially, students were overall suspicious of the VFT as they were disappointed to lose the in-person field trips and were unsure how the VFT would compare. Afterwards, all reflected that they would have preferred the TFTs over the VFT, but were understanding of the circumstances preventing that and appreciated the opportunity to virtually visit the locations and content. Each student interviewed recognised value and potential in the VFT as a learning resource, and learned from the experience.

Students benefitted from the VFT when the exercises and resources aligned with what they were intrinsically interested in, when the learning outcomes were well supported in the overall structure of SOSC223, and when the instructions and exercises were clearly written with enough supporting written or visual content in the VFT. They were frustrated and disengaged when these were lacking and when internet connectivity or other technical issues resulted in the maps and media in StoryMaps being slow to load or incomplete. Students found it difficult to work through the exercises without the ease of social

interaction with each other and the instructors that would happen in-person, and partially mitigated this by choosing to work online together or attending the Zoom tutorials we held during the assignment period. Although some students had difficulty self-motivating to work on the VFT, all appreciated that they could take breaks and return to it at will, and the ability to repeat and review the sites helped them learn.

5.2 Research question 2: What are the strengths and weaknesses of the SOSC223 VFT?

There is obvious overlap between analysing the strengths and weaknesses of our VFT and the issues affecting students' experience and learning on the trip. Despite this overlap, I chose to analyse and discuss these sections separately because they represent a shift in perspective. RQ1 focusses on *students* as an object of study while RQ2 in this section shifts focus from students to *the VFT itself* as the object of study. Through this shift in perspective I aim to further refine themes contributing to participants' experiences of success and frustration with the VFT, and ascertain whether they are strengths or weaknesses inherent to the modality of a computerised trip or contingent upon our specific context and delivery.

I begin by outlining and presenting evidence for themes characterising strengths of the VFT, followed by the challenges.

5.2.1 Strengths of the SOSC223 VFT

Flexibility and repeatability of the VFT

As outlined in detail in the previous section, the nature of the VFT as a standalone and repeatable resource helped students to learn and was something that they unanimously appreciated about the experience. Student 3 summarised this clearly:

> Well, I like the fact that you could just sort of do it anytime and you could always come back to it and you could do a little bit and then have a break and then, sort of, come back refreshed. And you, you sort of got more clear understanding rather than doing it all at once, but yeah, so that's probably what I liked about the virtual field trip is that you could just do it sort of leisurely. And you could sort of, I don't know, spend time on it. And think about it a bit more. (Student 3)

Students could work on the VFT at their own pace and repeat and review sites and exercises at will. The flexibility of the VFT gave students autonomy to manage their focus and workload. They could take breaks and return to work refreshed. The repeatability of the VFT

sites meant that students could spend as much time as they wanted reviewing content they struggled with and could use the trip as a study resource for the end of semester exam.

This result is in line with decades of practitioners' wisdom (e.g., Hurst, 1998; Stainfield et al.) and contemporary studies. For instance, students surveyed in Bond et al. (2022) appreciated both "learning at [their] own pace" and the "flexibility" of the virtual trip (Bond et al., 2022).

Visual connection to place

The visual materials - the maps, landscape models, photos, and diagrams - helped students to connect to the field sites. The examiner reasoned that the geographic context provided by the VFT was arguably better than on a TFT:

> I think it actually is better in the, in the geographic sense because you zoom out, you fly in, you know where you are. Even if you don't end up knowing where Barrhill is, you still know that you're part way up the Canterbury Plains on the south side of the Rakaia River. And . . . you know you're halfway between the gorge and Kaitōrete. Yeah, you can't not know that and you can . . . flip between the different sites. . . . It keeps reinforcing where you are, 'cause it takes you physically to that site each time. . . . There's an image of you moving from one place to another. (Examiner)

There are interactive features in StoryMaps that let you shift the view in a map from one location to another. We used these map view buttons in the narrative side bar so that students could see the movement between locations and how locations connected to each other. In addition to the built-in map view changes, it is possible to embed other visualisations of movement through the landscape. On in-person field trips on the Canterbury Plains, we expect students to notice and understand how the elevation difference between the modern river bed and Pleistocene-aged outwash surface changes as we travel upstream. We visit discrete sites on the Rakaia River but drive upstream on the nearest roads, not in the riverbed. On the VFT, we were able to include a video animation I made in Earth Studio that travelled from Barrhill upstream to the Rakaia gorge terraces. So long as students watched the animation before jumping to the next site, they would see the relief between the modern braidplain and the Pleistocene surface growing as the animation took them upstream.

One of the factors that was associated with increased student engagement and learning in RQ1 was the geographic context provided by the visual resources in parts of the VFT. To

reiterate key student perspectives, Student 3 appreciated that the VFT was “laid out in the way that you could see the maps. You could . . . interact with it and get your bearings”. They agreed with the examiner that interacting with the maps within and between sites let them understand where they were in the landscape and how the sites connected.

Student 4 became more connected to the field sites through our use of photos of landforms at each site. Some photos from past trips even included students doing the field activities we tried to emulate with the virtual exercises. This let Student 4 “see that they're up to date photos and not just ones off, like, a website or somewhere”. These personal touches added a sense of authenticity to the VFT, where including evidence of our experiences in these field sites allowed students to better connect to the vicarious experience of the VFT.

Visualising complex processes

One power of multimedia is its ability to portray models and representations of complex processes and augment an individual's perspective. Similar to how the VFT fostered students' connection to place through including interactive imagery of the landscape and authentic photos of the field sites, it could embed spatial data and visual representations of landforms and processes. Harkening back to one of the examples I pulled from the interview data showing how supporting context helped students learn, Student 5 found that the video on longshore drift helped them interpret the hooked bars of inland Kaitōrete:

> I found [the video] quite helpful just because . . . I sort of engaged with it more, but also I find it easier to link it to like the question being asked, so thinking, “oh, okay, so this is how it formed here, so how would that link to the formation of this question?” you know. (Student 5)

The video included a roughly sketched animation showing how longshore drift transports sediment, how spits can form across embayments, and how streamflow will keep the spit open. Seeing examples of modern spits and a broken-down visualisation of how they form helped this student to identify the landforms visible on the aerial map of Kaitōrete. The interpretation and synthesis already done in the video resource helped to guide their critical thinking to interpret part of the developmental history of Kaitōrete Spit/Barrier.

The VFT could visually display spatial data. The GIS maps and models in the Rakaia River sites communicated information such as surficial geology, soil type, landform, and sediment age. Student 3 recalled that:

> It was really good to look at it in that perspective. . . . You could turn off certain layers and sort of look at one thing and then turn it back on. (Student 3)

They could control what data was displayed and view the map at different sites or scales by panning across the map and zooming in or out. This helped them to interpret the landscape and understand how the data related to the landforms and processes occurring there. Interactive site-scale 3D models or an interactive regional map, like the one Student 3 referenced, can put landscape data into a spatial context that might be missing from verbal explanations. Clever use of GIS and 3D modelling can add rich information to help learners visualise and make sense of complex Earth systems. This result is supported within the existing VFT literature. For instance Pugsley et al. (2022) found students reported that learning using interactive 3D models helped to improve their 3D spatial thinking, Klippel et al. (2020) measured a greater increase spatial understanding from students attending their interactive virtual reality VFT compared to their TFT, and Bond and Cawood (2021) concluded that 3D models improved 3D spatial thinking compared to using traditional tools like photographs and maps.

Unfortunately, we did not have the capacity to take better advantage of the data visualisation capabilities of a VFT with our limited time and resourcing during lockdown, the technical difficulties we faced using ArcScene and CityEngine Web Viewer, and our inadequate written instructions in the VFT. Though the examiner incorporated geology, soil, and landform data into his 3D models and geomorphic map of the Rakaia River sites, to Student 3's enjoyment, most students struggled to use and understand the GIS with the amount of scaffolding and support we included in the VFT.

5.2.2 Weaknesses of the SOSC223 VFT

Scaffolding the VFT

The course examiner described his approach to teaching on field trips as a scaffolded way to build students' self-efficacy and interpretive skills:

> This perhaps applies more to slightly longer field trips, but the principle is the same – is that the information is scaffolded, meaning that [students] take on information and hopefully they can put it in some theoretical context based on what they're learning in class. . . . So my field trips are often . . . sequenced so that information presented early on lays foundations for understanding for what appears later on . . . By the end of the field trip there's the information that I'm expecting them to learn has been synthesized

> themselves rather than told to them like in a lecture but with the field as a backdrop. (Examiner)

The examiner aims to structure field trips such that early activities lay the foundation for experiences later in the trip. He elaborates with an example where students begin by making observations and descriptions of a field site, interpret it with their existing knowledge, and work together in the evening to synthesise the day's work into a growing story. Field exercises serve as a "practical experience where [students] are actively engaged and gaining the knowledge that's going to allow them to make the synthesis." (Examiner).

This is more difficult to do in the field on single-day trips. The examiner reflected that he doesn't think he's built the same level of scaffolded learning and skill development into the face-to-face day trips in SOSC223:

> I don't think I've achieved that on the day long field trips. They tend to be more compartmentalized and, and you know very well from SOSC223 that we retain that kind of compartmentalisation of it, it, when students present orally on a section, but the idea being that that provides, if the students do a half-decent job, it provides a resource for other students to use and hopefully some reinforcement for their learning and for exam preparation. (Examiner)

Although the design of the SOSC223 day trips is more compartmentalised than longer trips in upper-level courses, they are reinforced and supported by content elsewhere in the course. In a normal semester, each of the three field trips has a preparatory lab before the trip and an assignment associated with the trip. The Kaitōrete Spit and Rakaia River trips combine into a single assignment, where students create a field guide in Google Earth. The North Canterbury trip wraps up with a group assignment, where students work in small groups and give a class presentation on the geomorphologic history and processes influencing one of the sites of the trip.

This level of scaffolding was absent from the VFT.

> I don't know that I did a particularly good job of scaffolding information. Building, building from one thing to the next so that the last question . . . "Now tell us about how all of this fits in with a, with a broader-scale view of the evolution of the Canterbury Plains." So that's where we were probing that question, but honestly I don't think we built the scaffold well enough for them to answer that question well. So, I – I don't think I did it. I don't think I ported my style well. (Examiner)

> Both my part and [the examiner's] part were probably… They were not as scaffolded as they needed to be to be as effective as we would have wanted them to be. . . . We tried to include, I think, too much into it. (Myself, Self-interview)

We reflected that there was inadequate scaffolding of the content in the VFT for students to be able to answer the big-picture synthesis questions we asked towards the end of the trip, and the trip included too much content. This perceived failure is not intrinsic to the modality of VFTs, and instead is specific and contextual to our VFT. Before his interview, the examiner looked through the VFT and realised we may have "pitched [the VFT] at the wrong place."

> I looked at your questions and thought "ooh, I don't know the answer to that." Um, and I looked at some of mine and though, "Oh, wow…" it – sometimes it involves probably too many steps to get to the information, like, clicking on a map layer to get information from Qmap and, and then knowing… (Examiner)

Generally, the questions were difficult or required a high level of skill for students to be able to access some of the included information and then synthesise it to answer the assigned questions.

One of two areas that especially lacked support was the relevance of Kaitōrete Spit and Te Waihora to the system of the Canterbury Plains. Reviewing the VFT before his interview, the examiner noticed:

> The underlying theme [on the field trip] is what I talk to the students about – cascading systems, or conservation of mass, or some people might call source to sink. . . . We start talking about the sink and then we end up at the source. And try and pull those things together and emphasize the point that those two things are tightly coupled. The dynamics of the source - the glaciers bringing sediment out of the Southern Alps – has a big bearing on the sink behaviour – the fan. I think what, what was clear to me from looking over the Story Map, is perhaps, the link between . . . the toe of the fan and the Te Waihora Kaitōrete system isn't perhaps as well-linked as it should be. (Examiner)

The Kaitōrete section of the VFT was too compartmentalised from the Rakaia River section. Students recalled learning about coastal processes, the evolution of the spit-barrier system, and critiquing the management of the Wairewa | Lake Forsyth canal, but they were not led to link the coastal system to the processes occurring at the sediment source - glaciation in the Southern Alps - and its effect on the behaviour and development of the Canterbury Plains.

What the examiner describes above was the focus of the Rakaia River section that most students had difficulty with and did not complete. As I briefly mentioned in 5.1.4, students' marks for the Rakaia section of the VFT were so poor that we weighted their grades to the Kaitōrete section to match previous years' equivalent field trip assignment marks. We considered students' poor marks likely reflected the failure of our instruction, the scaffolding within the VFT, and the difficulties of lockdown, rather than a failure of the students. In his overall reflection of students' engagement with the VFT, the examiner stated:

> So generally I was, I was happy and I think that perhaps the lack of engagement on the Rakaia stuff may reflect that there's just too much, or it was too hard, and that needs reviewing. (Examiner)

A more concise experience or a better scaffolded trip that provided students with more guidance to think about how processes and landforms at individual locations fed into the regional setting would have helped students to make those big-picture connections.

Resourcing requirements of the VFT

Many of the scaffolding issues identified in the previous section resulted from the specific resourcing constraints we faced developing the VFT during Covid lockdown. The examiner and I had little time to develop the exercises and were limited with what materials we had at hand. We had access to an archive of photos taken on past field trips, geospatial data stored on the university's GIS network drive, and whatever open-source educational videos we could find, as well as access to ArcGIS software, Google Earth Online and Google Street View.

All of the media embedded into the VFT required us instructors to know how to create, upload, and troubleshoot issues with all the software we used. This is an additional requirement to the geographic and content knowledge of the field trip materials.

The express maps and global scenes in the Kaitōrete sites were designed by Esri StoryMaps to be easy to create. I found this to be true, though struggled to work through their limitations. When I became frustrated with the maps while creating the Kaitōrete Spit exercises, I vented:

> Okay… I can't add rasters or shapefiles to the express maps, just points and polygons… I CAN add images to points, so at least we can include photos in these maps. It seems like I cannot add anything to the 3D maps?? . . . No, that's only because I don't have the data or internet to do this without crashing… (Myself, journal August 2021)

I could add text, lines, and polygons to the 2D express maps, but they shrank the size of any photos I tried to add to location pins. I could not easily add data to the basemap web scenes so used them as an interactive, low-res model of the landscape. They were similar to Google Earth but without the ability to add location pins, photos, or text. The speed of my work laptop and my home Wi-Fi was too low for me to use any of the ArcGIS desktop or online programs to build better, information-rich maps.

The examiner was not constrained by his internet connection and built 3D models of the Rakaia River terraces using Lidar data in ArcScene, though this held its own frustrations:

> I was using ArcScene . . . and maybe that was again my lack of skill with ArcScene, but . . . it wouldn't drape properly and, and to make it work, I had to have this huge offset between the draped layer and the actual ground surface – and it's just – ArcScene's always been like that… I think it's probably the ArcScene limitation rather than anything else. (Examiner)

In addition to the examiner's needing to 'cheat' the ArcScene layers to display correctly, exporting the files to ArcGIS Online's 3D Web Scene into a file type supported by StoryMaps further broke the functionality of some of the map layers. We managed to fix the issue where a cross-section transect would not display in StoryMap, but this un-fixed itself sometime between publishing the VFT and my interview with the examiner:

> It was the porting that was weird and I also don't remember if it was porting the desktop into Arc Online and once that was fixed and online, it worked fine in StoryMap, or if it was an online, the StoryMap thing that was the issue, but there was, I remember there was some frustrating porting issues that… we fixed. But it seems like they didn't all stay fixed. (Myself, examiner interview)

Not only did the examiner need a computer powerful enough to run ArcScene, but we both needed enough skill with the programs to counteract software bugs. Resourcing a VFT requires hardware, software, and the time and technical expertise to create and fix informative and interactive resources. These resourcing requirements are the same for videos as for interactive models and maps. Notably, we did not have any instructional or introductory videos at the field sites nor could we go out to film any.

Nearly all students identified the lack of videos in the VFT. Their most frequent recommendation to improve the experience was to add short videos to each site, where an instructor would introduce the location, give verbal prompts for the accompanying activity,

and pan around the site. Student 4 succinctly summarised what four of the five student participants suggested:

> Like, um, maybe just like a short video of the lecturer saying like a few sentences are about what you're gonna do and stuff. And then like a short pan around the site. (Student 4)

Video introductions would provide students with some connection to the instructor and build expert guidance into the VFT. Moreover, they would give the sites more visual context by showing a ground view of how the surrounding landscape looks. Students described liking when the VFT provided authentic connection to the landscape through our use of our own photos (Student 4) or high-resolution 3D models (Student 3); perhaps introductory videos would add to the authenticity of the VFT. Furthermore, well-crafted videos could emphasise important features in the landscape that we want students to learn to notice on their own and could help scaffold learning and skill development.

However, this would require heavy resourcing to create. Designing and building a well-structured and appropriately scaffolded VFT that creatively incorporates visual, audio, and textual resources into a cohesive whole would involve months of work scripting, filming, editing, and more, and the money and equipment to do so. This would also require staff to have or gain the technical skills and knowledge *to* create digital resources like 3D models and panoramic videos. As Jacobson et al. (2009) acknowledges, the process developing a VFT is "involved, time-consuming, and costly" (p. 579). As the examiner exclaimed, just creating our ad-hoc VFT took:

> Oh gee – a lot of time. It was pretty much 9 to 5 for two or three weeks? . . .Yeah, it's a lot of time – and resources! (Examiner)

Access to technology

Many of the technical difficulties that negatively impacted staff and students' experience creating and using the VFT resulted from issues of access to technology. The functionality of the VFT in StoryMaps was heavily depended on users' internet connectivity and specific software, and how easy it was to use depended on the quality of users' hardware.

As Student 2 learnt, StoryMaps is browser-specific and would not load all the GIS on their Mac computer:

> I can't really do [the VFT] in my flat cause I did Apple and I couldn't use the GIS software on it, so I had to do it on the Uni computers, that bit. But I was lucky 'cause I . . . could use the remote [access]. I can sign onto the computer off my computer. (Student 2)

They were only able to load all of the maps in the VFT because they already had a remote connection set up to university computers running Microsoft.

The examiner and I were negatively impacted by our home set-ups when creating resources for the VFT. We both had only one screen - I only had my work-supplied laptop, and the examiner used an old monitor instead of his laptop screen. This made it difficult and frustrating to put together resources, whereas if we had had better equipment, the examiner reflected:

> I think if I – if I'd had big screens, multiple screens, and I could be seeing other things aside from, from this – that world and then alternating with another one… So, for example, you know the StoryMap and then ArcGIS and then if I could see the photographs I wanted to use on another one, I [sighs in relief], I'm out in the daylight rather than, you know, a closed room. (Examiner)

The examiner's poor set up left him with a sense of claustrophobia. Normally, we'd build something like this VFT from our offices on campus, but during lockdown we were stuck with what we already had at home. With limited access to technology, our work was further constrained beyond the existing time and resource constraints of lockdown.

The most widespread technical issue with the SOSC223 VFT was users' internet access. The maps embedded in StoryMap required a stable internet connection to load quickly and without error. Of all the students I interviewed, only Student 1 had a stable enough connection to experience no glitches or slowness. My connection was so poor I could only use basic features in the easy express maps and web scenes and left all the creative models and more involved GIS to the examiner. Student 3 lost their first assignment submission because their internet cut out while they were submitting it, and nearly everyone was frustrated by the slowness and glitches.

Our experiences and frustrations with the VFT illuminates an issue of equity of access to technology. Not everyone can afford or prioritises purchasing high-quality computer hardware such as a fast computer and multiple screens. Internet access similarly comes down to a mix of people's economic status and national infrastructure. In my case, it was cost; it is cheaper for me and my housemate to share a phone plan with unlimited data and

hotspot Wi-Fi off our phones than it was to have a data-less phone plan and have home internet. Our finances are such that the amount we save is a noticeable part of our monthly budget. This was fine until lockdown, where 3 days of working from home ate through my fast-speed data and I was on reduced speeds until our plan renewed.

Student's internet connectivity was the decision of landlords or a result of where they lived during lockdown. The university's Wi-Fi is notoriously poor and the campus dorms do not have Ethernet connection, so students living on-campus during lockdown were stuck with internet that frequently drops. Students who live outside of large towns or city centres would not have access to fibre, and might depend on wireless coverage, which is slower and less reliable than other broadband options. Figure 5.1 is a snapshot of cabled and wireless broadband coverage in Canterbury; even wireless coverage is limited.

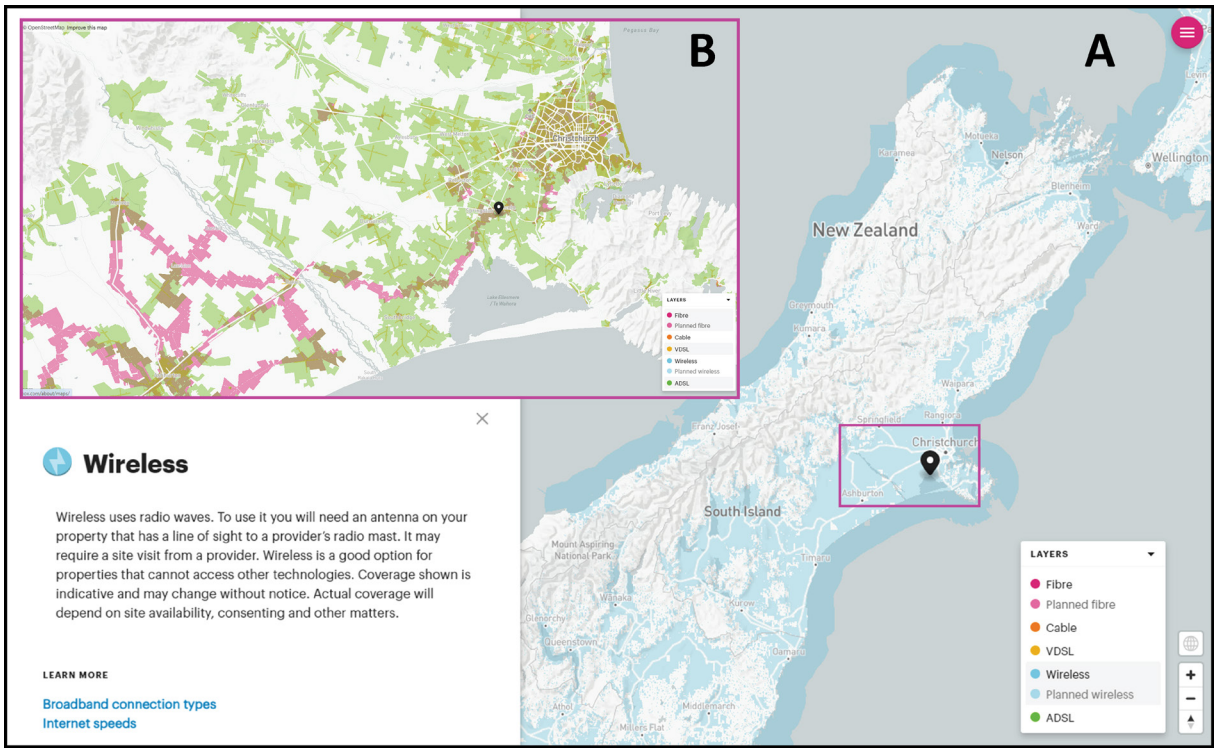

Figure 5.1 A) Wireless coverage of the South Island. Pin is set at Lincoln University. B) Fibre and broadband coverage in Canterbury. Adapted with permission from web maps provided by InternetNZ on broadbandmap.nz.

In assessing our experiences with this VFT, it is clear that although the flexibility of being able access the VFT from anywhere with internet is a benefit of this medium, its dependence on computer equipment and stable internet, combined with the cost and availability of technical infrastructure, negatively impacts its accessibility.

Interpersonal connection

As I previously discussed when addressing RQ1, social connection was lacking in the VFT. Most students said they missed having what Student 1 referred to as the "discussion aspect . . . between yourself and the lecturer and between yourself and the other students". The examiner and I also remarked on how difficult it was to facilitate interpersonal connection using the VFT. Referencing an earlier point in his interview, the examiner stated that:

> [The VFT] doesn't provide those really important things we talked about, with the community, the sense of community, [with everyone] all locked into their own [separate spaces]. (Examiner)

We ran the VFT mostly asynchronously. I would proofread and upload each new site to the published StoryMap and students worked through the sites and exercises in their own time. Working at home on computers left students more socially isolated than in in-person class sessions. In labs or in the field, students can discuss content with each other and ask quick questions. Instructors can check in with the class in real time to gauge what they are understanding or stuck on and can provide direct guidance and explanation. During the VFT, the examiner and I were available to answer questions via email or in the Zoom sessions, but unlike in-person dialogue, neither of these methods of communication were immediate. Students had to wait for us to respond to emails or hold their questions until the next video tutorial to ask us face-to-face.

Although we attempted to facilitate class discussion by holding twice-weekly Zoom tutorials while the trip was running, they were not successful at getting the entire class engaged and asking questions. The sessions were voluntary and had low attendance. The largest tutorial had only three students attend, and most only had two out of a possible nine. Of the students interviewed, Students 1 and 3 each attended one session, Student 4 and 5 attended two, and Student 2 did not attend any despite wanting synchronous working sessions. In their interviews, Students 1 and 2 entirely forgot we had held tutorials, and while I failed to follow up on why that was the case, the context of how both describe a Zoom session suggests a different tutorial style than the student-directed discussions we held:

> I know it was all quite logistically hard, and you guys had like a time crunch and that kind of thing. But if we could do like a like a Zoom call where that is, [the examiner's] going through it and that kind of thing, and he's like explaining it. I feel like that would work best. For those sorts of tools. (Student 1)

> Maybe if we did like a Zoom class, or like a computer class, where we could work on it together. Something like that. (Student 2)

The tutorials we held were unstructured and relied on students to bring their questions from sites they'd already worked through. Instead, Students 1 and 2 wanted a synchronous class session where they could work through the VFT together with their peers and with the instructors providing timely feedback. They thought that more structure, direct guidance, and working together would help them make the most of the VFT. As it stood, easy interpersonal connection was absent from the VFT, which led to insufficient dialogue and instructor guidance, missing social interaction and peer support, and left little opportunity for students or instructors to develop a sense of community.

5.2.3 Summary

Challenges in the VFT arose related to access to technology, content scaffolding within the trip, and interpersonal connection. Poor internet connections caused maps and media to freeze and glitch and the quality of VFT sites varied. The resourcing restrictions of lockdown resulted in limited support and scaffolding by adequate instruction and fully-integrated multimedia. And even had we had materials and time to design a fully-functional, well-resourced VFT, the resourcing requirements to do so are substantial. Everyone missed the easy dialogue that occurs during TFTs and unscheduled opportunities for asking questions and receiving guidance outside of Zoom calls and email. Yet benefits emerged from the flexible and repeatable nature of the VFT, and the potential for well-designed interactive multimedia to facilitate students' visual connection to place and ability to visualise complex processes.

5.3 Reasearch question 3: How does the SOSC223 VFT compare to TFTs in tertiary earth science education?

In this section I compare what participants valued or found challenging with traditional field experiences to the affordances and drawbacks of the VFT identified in RQ2. Three categories emerged from the data, including logistical impacts relating to the flexibility of running field trips, effects relating to physical immersion in a learning experience, and effects relating to social presence in a learning experience. Sub-codes within physical immersion and social presence naturally grouped into themes of *experiential learning* and *embodiment* for physical immersion, and *community building* and *expert guidance* for social presence. I will

briefly introduce learning theories relating to these themes and discuss the results as they relate to these theories and to relevant literature on field trips in the earth sciences.

5.3.1 Logistical impacts relating to the nature of TFTs and VFTs

Perhaps most obviously, TFTs and VFTs differ in their fundamental set-up and the challenges and opportunities that each teaching mode affords. In-person field trips are one-off events that are a substantial commitment from attendees; students who cannot attend are disadvantaged, and adverse conditions or fatigue on the day can detract from the experience. VFTs are a modular resource. They can be scheduled synchronously, asynchronously, or a flexible combination of both, and students can revisit sites and take breaks at will.

TFTs: Rigid and singular

The logistical challenges of running TFTs are long-established in earth science education literature (See Boyle et al., 2007; Kent, 1997). These include, but are not limited to factors like cost, weather, and transportation. Though all students I interviewed for this project valued field trips, they described downsides relating to the inflexibility of TFTs as single, isolated events.

TFTs are often a day, sometimes a weekend or week-long trip scheduled far in advance. The rigidity of their scheduling can impact student learning on the day or disadvantage students that have course clashes. A recurring pattern in students' interviews was how busy they are and how many responsibilities they must prioritise and manage. Most mentioned needing to deal with trip clashes and making up missed work, illustrated by Student 3 and 4's responses below:

> Usually I quite enjoy going on in person field trips, but, sometimes if you had like a class on that day and that you know you're gonna miss out on, it can sometimes be a bit of like an added, like burden. (Student 3)

> Some of my courses, their field trips were multiple days long, so I feel like you're missing out quite a lot and then they go into the weekend and no one really wants to be in the middle of nowhere on your weekend. Especially when it's compulsory. (Student 4)

Field trips can add extra stress to students' workload. If students have multiple courses going on trips on the same day, they have to choose which trip to attend. Even without competing trips, students often need to make up missing classwork. They can watch recorded lectures,

but labs or tutorials are harder to understand through copying a peer's notes if they miss an experiment while on a field trip. Additionally, students may need to re-schedule their work roster, or miss personal or social events. Students 3's response implying that the benefits of attending field experiences outweighed the additional responsibilities of making up missed coursework was typical for the participants. Student 4, however, found that the additional stress and work greatly impacted them and their desire to be in the field. Field trips, especially ones going over multiple days, are a substantial and inflexible time commitment that, while generally perceived to be “worth it”, may negatively impact students' wellbeing when managing heavy workloads.

Three of the five students I interviewed discussed fatigue and overload as something that negatively affected them on field trips. Student 1 provided the most detailed explanation:

> On a field trip it can be, you know, a full day of information being crammed into your head and by the time you get to the last part of the field trip it can just be like a bit… sort of like an overload of information. And it can get quite tiring. It’s always the start of the field trip where that information seems to sink in but then by the time you’ve done a full day of going through things that’s when everyone starts yawning and looking a bit tired and ready to go home. (Student 1)

After a full day of travel, activity, and learning new information, students can be too tired to focus on the final activities of the day. As a result, Student 1 better remembers information from earlier on trips than towards the end. Student 3 reflected that after a long days “there [are] always minor things . . . [that aren't] minor, that you sort of forget” and Student 2 shared that field trips can “sort of drag on a bit . . . you lose interest and just zone out”. Unfortunately, it is difficult, if not impossible, to replicate a field setting in the classroom, so any content or practice that students miss if they're disengaged cannot be re-taught to them in the same manner as on a field trip. Students can review lecture material or have a verbal debrief, but practicing specific field skills or being immersed in a particular environment are limited to the field trip. As Student 3 stated, TFTs are “sort of a 'once' thing”.

Poor weather also adversely affects students' experiences. Three participants independently mentioned rain as a downside of past field trips. Student 2 described their engagement on field trips as “weather dependent”, and Student 3 mentioned:

> There’s the odd time when it’s pouring down with rain standing there, but. In those circumstances, you’re not always, you don't always take it all in. (Student 3)

A downside of being physically in the field is that the weather will be whatever it is on the day. Being cold and wet is detrimental to anyone's focus! Rain or strong winds can make access to sites unsafe and cloud or fog may obscure the landscape, making fieldwork difficult or impossible.

Conversely, on a field trip looking at Earth surface processes, poor weather may better demonstrate processes in action. Students can see, hear, and feel waves crashing onto the shore and moving sediment and driftwood across the beach, or the wind blowing sand past where they stand and into the dune system. Calm days are more pleasant to work outside, but leave behind only evidence of the higher-energy processes affecting the coast rather than showing those processes as they happen. Regardless of the weather on the day, students only experience a snapshot of the location as it appears under those specific conditions.

VFTs: Repeatable and flexible

The nature of a VFT as a digital resource that is independent of access to a physical location at a specific time allows for a level of flexibility, autonomy, and modularity absent from most TFTs.

Students' experiences in the field are limited in scale to field site, to what observations and measurements they are able to make at the site, and to the physical conditions of the field on the day. What students experience in the field is limited to site-scale and what observations or measurements they are able to gather at the site as well as the physical conditions of the field on that day. A VFT, however, can provide visual resources that show the site under different conditions, illustrate change through time, provide different scales of view, and display spatial data (see Hurst (1998), for example). A VFT is thus modular, where multiple sets of visual data can be woven into a more-comprehensive whole. Although we were limited in what resources we could create and include in the SOSC223 VFT, students appreciated being able to see the regional and site-scale maps and resources. Indeed, two strengths of the VFT identified in RQ2 were being able to use multimedia to visualise complex processes and foster students' visual connection to place.

A VFT is also repeatable. Students were not limited to their time in the field to review and reflect on the content of a field trip. Instead, students could repeat VFT exercises at will and

use the resource to check their understanding and study for their exams, as four of the five students mentioned doing. To repeat Student 5's comment on the VFT as a resource:

> I think it's good as a learning tool because you can go back and . . . have it as like a reference, especially when studying for exams. You can go through and look at, “oh okay in this example that this is how I answered it.” Or, “this is what I learned from that question.” (Student 5)

The flexibility and autonomy provided by the VFT was another strength identified in RQ2. Unlike a TFT, where students fit their schedules around the field trip, in the VFT, students could work through the trip to their own schedule. Most students mentioned liking the autonomy this provided them. They did not have to miss other coursework and could take breaks and return to the VFT refreshed instead of struggling through end-of-day fatigue on a TFT. As Student 4 reported, the scheduling autonomy of a VFT “took off some of the stress” compared to a TFT.

Nearly 30 years ago, Hurst (1998) identified advantages to running computerised field trips, including displaying information at different scales, displaying non-observable data, repeatability, flexibility, and removing logistical barriers (Hurst, 1998). The affordances of a VFT outlined above resulting from its flexible, modular, and repeatable design as outlined above closely align to those described by Hurst (1998) and reiterated in practitioners' wisdom published in the decades since (e.g., Peace et al., 2021; Stainfield et al., 2000; Tuthill & Klemm, 2002).

5.3.2 Experiential learning and embodiment

Experiential learning theory, based on the philosophies of William James, John Dewey, and Jean Piaget amongst others, holds that learning is “the process whereby knowledge is created through the transformation of experience” (Kolb, 2014, [1984]). Kolb's model of experiential learning describes a four-stage learning cycle involving a concrete experience, reflective observation of that experience, abstract conceptualisation based on a learner's experience and reflections, and active experimentation to test conceptualisations. The physicality of experiential learning can lead to embodiment through sensory input and movement through a contextually-relevant environment.

Embodied theories of learning highlight the close links between physicality and cognition (Kiefer & Trumpp, 2012). Mogk and Goodwin (2012) summarise embodied learning

frameworks as “the idea that psychological processes, including ideas, thoughts, concepts, and categories, are influenced by the body's morphology, sensory systems, and motor systems as they interact with the natural and social environments where learning occurs” (pp. 134-135).

Throughout their interviews, students demonstrated that they valued embodiment and experiential learning in their education. They compared the VFT to their previous experiences on TFTs where physically seeing and interacting with real-life phenomena on in-person field trips formed memorable experiences and helped them put theory into practice.

Experiential learning and TFTs

Morris’s (2020) systematic review and revision of Kolb's experiential learning cycle places emphasis on real-world contextualisation. He found that educators conceptualise experiential learning as a processes where learners have concrete experiences within “contextually rich” learning environments, that “critical reflective observation is essential” to create meaning in these environments, and learners test and form abstract conceptualizations in context through and against new experiences.

In the examiner's estimation, field trips are valuable experiences in one of two major ways. One way is through building community, which I will discuss later in section 5.3.3, and the second is the authentic application of theory to real-life context. In his words:

> The obvious thing is that [a field trip] takes the discipline, the – of what you’re doing, in this case geomorphology, or it can be soil science, into the world where it actually resides. So you're looking at landforms, looking at soils – real, real ones in the landscape, rather than in the classroom. (Examiner)

The examiner’s view of field trips has obvious parallels to experiential learning. Field trips are a concrete experience in which students can apply their classroom theory into a contextually rich “real world”. In the case of geomorphology field trips, students can see real landforms and processes occurring in the landscape.

Students also valued the practical application of their classroom knowledge to a real-life context as central to the role of field trips.

> I think the purpose was probably to, um, have something that we we've learned those things in class and then go on a field trip to sort of, um, add that extra, or, solidify that extra sort of relation between context in real life. (Student 3)

> I think that the main purpose of the field trip is being able to go out and . . . see what we've learned in class so we can link it to what we've learned in lectures. (Student 5)

> You get to put the stuff you've learned into a practical aspect and now you can see like what this, like, if you've learnt something about like ecology, you can put that into perspective. (Student 2)

As Student 2 states, the practical context of the field changes students' perspective of their learning from something theoretical to applied. The field trip provides a contextually rich concrete experience, where students can critically reflect and compare their theoretical understanding to their new experience in the field and create new context-specific abstract conceptualisations. The contextualisation of abstract concepts through rich learning environments as provided by field trips is a core aspect of experiential learning (Morris, 2020).

Embodiment on TFTs

I had some difficulty coding participants' data regarding experiential learning and the embodiment of physical presence in the field. Within the same response, and often in the same sentence, students would refer to some physical aspect of being immersed in the landscape in context with a practical experience and application of classroom theory. Similarly, Morris found the literature on experiential learning to assume embodiment as a core aspect of experiential learning, stating, "Embodiment is a central consequence of immersing learners physically in the learning space." (Morris, 2020, p. 1071) and an area needing further research.

The visualisation of concepts was important to students:

> For me it's quite important again just linking to that being able to visually see and interpret what I've learned in the class. (Student 3)

Physically being in the field allows Student 3 to see and critique their existing understanding. An interesting thing in most students' interviews was them referring to sight as a proxy for physicality. Here, "visually see" implies a first-hand experience rather than the vicarious sight of a VFT.

Student 5 refers to a similar link between visualisation and in-person experience when they brought up a past laboratory where they experimented with a stream table:

> Yeah, being able to actually go and see those in real life and look at them and see like, when we poured water on them, seeing how the water flowed down the different levels

> and stuff like that. So, yeah it's just for me I'm a real visual learner, so being able to do it in person, is better for me. (Student 5)

In this lab, students did not just passively observe water flowing down a table filled with lightweight sediment. Instead, they were actively involved in changing the discharge of the water onto the table, adjusting the tilt of the table, scooping out or adding sediment to the streambed. They hypothesised how each change would affect the model river, enacted the change, and observed the changes in real time. Though Student 5's example is for an in-person laboratory we ran using a physical model, they relate their experiential, full-sense experience in lab to what they would experience on an in-person field trip in a natural setting. Being in the field allows them to interact with the environment and observe processes in action.

Student 2 directly compared their learning on the VFT with our post-lockdown SOSC223 field trip to North Canterbury:

> I found the North Canterbury one a bit more, took a bit more off it, 'cause I was, you could see it more in person and… that you could take away, like if [the examiner] was pointing out the landscape you could actually see the features. (Student 2)

In the field, Student 2 could see everything around them instead of being limited to the computer screen and visual resources in the VFT. They had agency over their body in the landscape and could physically shift their gaze to follow features instructors directed them to. They link their increased field of view and ability to follow instructors' guidance from being in the landscape to deeper learning and memory.

Student 3 commented on the same TFT, saying:

> It's real, and it's quite raw 'cause it's in your um – you're there and you're sort of like, in a way it sticks… well personally it sticks with me. (Student 3)

The North Canterbury field trip provided a "real", raw experience that deepened their learning of the content.

Embodiment theories propose a close link between cognition and the sensory and motor brain systems, where relevant sensory-motor interactions with the environment during learning leads to stronger and richer knowledge development (Kiefer & Trumpp, 2012). On TFTs, students have "raw" experiences, where they directly observe and interact with the surrounding environment and recall those first-hand experiences more strongly than their vicarious experience on the VFT. The results of this study support Mogk and Goodwin's

(2012) argument that embodiment is an important component of learning in the field, where movement and gesture guides focus and helps learners make sense of spatial relationships in the surrounding environment.

Experiential learning and embodiment on VFTs

The VFT did not afford the same opportunities for embodiment and experiential learning as do TFTs. In stating their preferences for TFTs, students emphasised their enjoyment of practical work and being able to apply theory to real-life context on TFTs and stated how the raw experience of being physically immersed in the landscape helps them to better see and understand the landscape. Some outright stated and others implied that their experience on the VFT did not afford them the same connection to the environment and their learning. For example, as Student 5 said, while the photos in the VFT added some visual context and helped to engage them:

> I think for that it might have been nicer to be there in person 'cause you can't necessarily judge like height or something from a photo. (Student 5)

The immersion of a TFT provides students with a sense of scale missing from the vicarious experience of the VFT. However, the VFT was not devoid of opportunities for engagement and connection to the landscape. As I mentioned within RQ1 when discussing the factors that supported or detracted from students' learning, the materials in the VFT engaged students when they provided sufficient context to the location and course content.

One example of this was the longshore drift video and associated questions, which directed Student 5's thinking and helped them apply their understanding of coastal processes to the landforms visible in the aerial map of Kaitōrete Spit.

A second example was Student 3's experience with the exercise involving the interactive geomorphology map of the upper Rakaia River. They recalled that it was good to look at the landscape in an overhead perspective with the extra benefit of being able to turn spatial data layers on or off. They reflected:

> You wouldn’t even be able to sort of do that on a normal field trip, obviously, so I think that was really beneficial because . . . you could turn off certain layers and sort of look at one thing and then turn it back on. (Student 3)

Visual resources that provided context and perspective to the landscape and landforms and processes occurring within added authenticity and a sense of connectedness to the landscape. While these exercises were not a full-body embodied experience, students'

interaction with the maps and media served to develop their understanding of the landscape and "get [their] bearings" (Student 3) and deepen their geographic connection to the sites. The novel perspectives of spatial data in the geomorphology maps and models of the Rakaia, and the conceptual breakdown of coastal processes in the longshore drift video alongside aerial footage and photographs of the landscape on Kaitōrete added context to the VFT experience, allowing students to test their existing theoretical understandings to the landscape and landforms they could observe in the VFT.

Unfortunately, as evidenced in RQs 1 and 2, the GIS maps and models did not consistently work for all students, which detracted from student's engagement and learning. Our resourcing constraints meant that the VFT could not be structured to be pedagogically aligned to Kolb's experiential learning model or include fully-functioning interactive materials to build authenticity and foster students' connection to the landscape. Nevertheless, moments of success with our VFT where students connected to the sites and content indicate that VFTs have the potential to be rich, meaningful learning experiences by providing novel perspectives that are impossible or impractical to achieve in the field. This conclusion is supported in recent literature on the use of 360° photography, 3D models, and virtual reality headsets to promote connection to the virtual landscape (Bond & Cawood, 2021; Klippel et al., 2020; Pugsley et al., 2022).

5.3.3 Community building and expert guidance: Situated learning

Many learning theories emphasise a social component to learning. Within geoscience field education research, Lave and Wenger's (1991) theory of situated learning is an increasingly-used theoretical framework (e.g., Donaldson et al., 2020; Mogk & Goodwin, 2012; Petcovic et al., 2020). Like experiential learning, situated learning holds that learning occurs in authentic contexts, though the focus in situated learning theory is on authentic social contexts. Learning happens through legitimate participation within a community of practice (Lave & Wenger, 1991). Petcovic et al. (2020) categorise the components of situated learning to include *content*, as a process of skill acquisition through guided engagement in expert practice, *participation*, to describe how learners interact with new experiences and knowledge to develop identity within the practice, and *community of practice*, where learners build relationships with each other through shared experiences and practices within a shared domain of interest (Wenger-Trayner & Wenger-Trayner, 2015).

On field trips, students build community with each other and with knowledgeable instructors and receive guidance to develop skills and identity within their discipline.

Community building on TFTs

The social environment of a traditional field trip, where everyone travels together to a new location, helps to create a sense of community and teamwork. The course examiner reflected that field trips change the learning environment and reduce formality:

> The formal "teacher in front, students sitting down," the one-way dynamic . . . of information going one way and not the other, can be broken down. The informality [of field trips] can facilitate that two-way exchange of information. And I think because students become more socially connected. That is, they'll often sit on a bus together, or a van, or they walk together - gives them a sense of community. And confidence, often in that community, and that confidence will often allow them to interact with more… with less self-consciousness.

He holds that the social atmosphere of field trips comes from two things - instructors facilitating dialogue in the field instead of a one-way lecture, and the chatting and bonding students do during down time on trips. These foster a sense of community in students and provides them confidence to engage with the trip.

Students similarly recognise and enjoy building community on their field trips. Almost all mentioned liking working in small groups or teams, which Student 4 linked to helping them to learn more deeply. They said:

> I really like the practical work and when everybody, like, in the group is really . . . when they really get into it, it feels like a proper sort of environment that really helps with learning. (Student 4)

They enjoy the when they and their classmates are engaged with the field activities. The social learning environment that forms when everyone is engaged in the fieldwork and working collaboratively stands out to Student 4 as a key positive of field trips and learning in the field.

Student 3 wants their trips be interactive and collaborative in this way.

> I personally enjoy the field trips where you're sort of interacting more. I've been on some where you're just standing there, sort of listening to a person the whole time. And I quite enjoy it when . . . you're the one sort of like… being interactive and asking questions and… yes, it's sort of, you're involved in a way, not just standing there taking notes. (Student 3)

They do not want a field trip to be an outdoor lecture, they want to be an active participant in field learning and engage in dialogue with the class.

Peer conversation and dialogue helps Student 1 to learn.

> Like if the lecturer was explaining something, sometimes you got a classmate who understands it more than you and you're standing next to them and you can just quickly talk to them about it like "oh what did he mean by that?" and they'll explain it to you. (Student 1)

If they are confused by what an instructor is explaining on a field trip, they can easily turn to a peer and ask them explain the content in a different way. The informality of the field trip leaves room for students to become instructors and help each other learn and build skills. They can work collaboratively more effectively than when sitting as passive individuals in a lecture.

Expert guidance on TFTs

Student and instructors' physical and social presence on in-person field trips also allows students to quickly ask questions or seek feedback and for instructors to provide direction and guidance.

Multiple students mentioned being in the field prompted them to think of questions they otherwise might not have had.

> It's good to have you guys there too, 'cause I think when you're on a field trip, you're… What I found for me, I always had like questions that would pop up just because you're there, experiencing it, so it was good to sort of have people there who knew and then they could explain it in real life, then you can kind of see it. So, that was always quite good. (Student 3)

> It's just the interpersonal aspect of being able to stand there with yourself and [the examiner] and look at something and ask the questions that I need to ask in order to be able to visualize why something looks like what it looks like. (Student 1)

For both Students 1 and 3, having knowledgeable instructors available to answer their spontaneous questions helped guide them to visualise the processes they were learning about on the field trip. Student 1 continued to explain how direct engagement with instructors helps them learn:

> My favourite part about field trips is… oh that's actually a tough question. It's, I think having more of the opportunity to have like one on one time with the lecturer and have

> them explain concepts to you a bit more directly because um obviously just that one on one time is really good for building a bit of understanding about something that you struggle to understand. (Student 1)

They find that on field trips they are able to have individualised instruction which helps them gain understanding and confidence in concepts and skills they otherwise struggle with.

Students also appreciate how having instructors direct their focus helps them make sense of a field site. Student 4 explained that their ideal field trip would involve instructors providing demonstration and individualised help.

> The lecture is explaining sort of, ah, what's the word, demonstrating what to do, and then there's, like, helpers, that go around when we're in our groups doing what we're supposed to be doing. That could be like doing tests on things, or like trying to find species or something and name them and stuff like that would be pretty cool. (Student 4)

They described a scenario where the main instructor provides direction of how to perform professional field work and additional instructors float between groups to provide general support and individualised help. A strength of traditional field trips is the potential for this type of direct guidance from a knowledgeable instructor, where they can help students build skill and confidence in the field and practices of the particular discipline. This is akin to the master/apprentice model from which Lave and Wenger developed the theory of situated learning and communities of practice.

Proponents of situated learning within the earth sciences argue that field trips and field work are situated within physical space, within the practices of the discipline, and within a community of students and instructors (Mogk & Goodwin, 2012; Petcovic et al., 2020). The values and experiences shared by participants in this study align with this argument. Being physically in the field as a group allows the class to build community, ask questions, and receive direct guidance and mentorship - all facets of developing identity within the discipline and community of practice.

Community building and expert guidance in the VFT

Interpersonal connection in the SOSC223 VFT was one challenge identified in RQ2. Both students and instructors found it difficult to engage with each other. There was insufficient dialogue, less instructor guidance and mentorship, and less opportunity for camaraderie compared to a traditional field trip.

The informality and physical proximity of people on a TFT allow students to engage in dialogue with each other and with instructors. Peer discussion and two-way dialogue were missing from the VFT:

> Probably the main annoying part was yeah just not the like having the discussion aspect as much between yourself and the lecturer and between yourself and other students. (Student 1)

Although four of the students I interviewed partially overcame the lack of discussion by working together on the VFT sites, and the examiner and I tried to facilitate discussion in the tutorials, the VFT was far more isolating than our in-person field trips. Students worked in their own time and there was no convenient way for them to work together outside of texting or video calling each other. There was no default downtime during travelling or on lunch breaks for the class to relax and chat. Though the examiner and I tried to begin the tutorials by asking students how they were doing and leaving space for informal chats before answering questions, these were brief and felt forced.

On a TFT, students think of spur-of-the-moment questions and are able to promptly ask them to the instructors or their peers. On the VFT, students could not ask impromptu questions as they would in the field. As Student 4 stated:

> I did struggle with it a bit to get through all the questions, and since you didn't have someone there, you couldn't ask about like the wording of some questions. (Student 4)

Students could only seek clarification or check their understanding asynchronously through email or by saving their questions for a tutorial session. Most reported that they wanted more guidance within the VFT, either through synchronous work sessions and instructor direction, or with introductory videos at each site. For example, Student 4 suggested including:

> A short video of the lecturer saying like a few sentences about what you're gonna do and stuff. And then like a short pan around the site. (Student 4)

Without introductory videos, the VFT relied on narrative text and the linear flow of the maps and resources included in the StoryMap to direct students' attention. This did not provide adaptive guidance or mentorship in the way that knowledgeable instructors can provide immersed in the landscape. Including introductory videos would provide additional context and direction for students, and running a synchronous VFT, either virtually or in-person,

would give more opportunity for instructors to re-direct students, share additional information, and answer questions, and allow students to more conveniently work together.

5.3.4 Summary

The SOSC223 VFT differed from TFTs in how the mode of delivery impacts students' social and physical immersion within the learning experience and the logistical constraints and affordances of each. Learning theories of situated learning, experiential learning, and cognitive embodiment are core aspects of traditional, in-person field experiences, where students' physical and social engagement in the field forms memorable events, deepens their learning and enjoyment, and builds their sense of identity in the discipline. The VFT lacked the same types of engagement due to its isolated and asynchronous set-up and resourcing constraints - its overall design lacked coherence to foster social and geographic connection. Though the asynchronicity of the trip hurt the class' connection with each other, it aided students in other ways. The flexibility of the VFT as a repeatable, modular activity gave students autonomy to fit the trip within their schedules and workloads, take breaks, and reflect on and review their understanding of the content in a way that is difficult to achieve in a time-limited TFT. Additionally, the ability of the VFT to display a variety of non-observable digital data, include interactive models of the landscape, and illustrate changes through time provided context-rich opportunities for students to connect with the VFT in a way that complements the field skills and understandings students might gain on a physical field trip.

5.4 The future of the SOSC223 VFT

The final section of this chapter outlines participants' suggestions to improve the SOSC223 VFT, their insight into best-practice VFT design, and the examiner's and my intentions for integrating the VFT into the SOSC223 field trip curriculum.

Throughout the semester students and instructors became familiar with the mode of VFT teaching and learning. While reflecting on their experiences during their interviews, participants provided valuable suggestions to improve the VFT and insight on how and when VFTs could best be used as an educational tool in tertiary earth science education.

5.4.1 Student suggestions for improvement

Most students wanted more guidance built within the trip. Student 1 suggested this look like a pre-trip lecture:

> We could sit down and have a lecture, or we could include it in . . . other lecture material, sort of like a case study like what we did on other parts of the [course]. Wo we have that sort of book knowledge going into it and we know what we're looking for a bit more. . . . So it's like if, just as a hypothetical, that was one of the locations we visited on our field trip - on a virtual field trip - we'd be able to look at it and have a better understanding leading into it. (Student 1)

For a VFT run in place of a TFT, an in-class introduction to the locations, content, and expectations of the field trip would prepare students to better engage with the VFT. This is akin to best-practice field trip pedagogy, where introductions and debriefings are considered integral to best engaging students in the field (Kent, 1997; Lonergan & Andresen, 1988).

Student 2 wanted guidance after the trip in the form of a class debrief "going over some of the questions on the field trip that maybe we got stuck on." Our debrief was minimal. We provided written feedback to students' assignment submissions but did not prioritise running an in-class debrief in the scramble of exiting lockdown, returning to socially-distanced teaching, and the uncertainty of organising the end-of-semester trip, which we were able to run in-person. A formal debrief would have allowed students to directly ask us question, and would have let us reinforce key learning outcomes.

Other students thought more guidance could occur within the trip itself via video introductions to the sites:

> Maybe just like a short video of the lecturer saying like a few sentences are about what you're gonna do and stuff. And then like a short pan around the site. (Student 4)

Videos would reduce the self-directedness of the trip by providing verbal context and direction. They would also provide richer visual context of the field sites. Student 2 suggested that videos should be included in addition to clearer labelling of all supplementary photos:

> Just like the labelling of the photos again, or like, or maybe like a video of you saying like this, this feature here. (Student 2)

Labelling all visual resources would provide further context to the field sites, especially in the case where the photos were small and difficult to use as they were in the maps that

frustrated Student 2. Improving existing resources and creating and incorporating more audio-visual resources would give more authenticity to the virtual trip and make information more accessible than through text alone.

Generally, students suggested streamlining the trip. For Student 4, this would look like refining the questions and exercises to be easier to understand and link together. They wanted “less sections so it's less spread out” with shorter questions and better integration of non-textual information for those who are “better at listening than reading” (Student 4). One of Student 3's parting comments was simple and poignant:

> I reckon, if it's laid out quite well and like really easy to use and navigate, then I can definitely see advantages of it. (Student 3)

Students' suggestions are ways we could improve the VFT from an emergency replacement trip to something developed with care and thought. Integrating the VFT into SOSC223 through intentional introduction and debrief is better course design and field trip pedagogy, and increasing visual context and instructor guidance with better-designed imagery and short introductory videos would mitigate some of the weaknesses identified in RQ2. Additionally, improving guidance and mentorship and providing well-designed exercises with rich data and in authentic, even if virtual, contexts would better align the VFT to key features of situated and experiential learning theories.

5.4.2 Student suggestions for integration

All students thought the VFTs could add to their university education. Most considered them appropriate supplements to TFTs, replacing an in-person trip only if necessary. As Student 2 summarised, a VFT could be used as a backup:

> For international students, if they can't do the field trips like you can make a bit more appeal to the course, or if there's a lock down or bad weather or something like it’s a really good option, so students don’t miss out on that learning. Or if people can't go on the field trip because he's sick or something, they can do the virtual one. (Student 2)

As highlighted in RQ3, a VFT is more logistically flexible than a TFT. One could be run instead of a TFT if an in-person trip cannot be held, or could be used by individual students if they cannot attend the TFT. As Student 2 stated, using a VFT as a backup would make it so students don't lose the entirety of what they would experience on the missed TFT.

A VFT could supplement a TFT by serving as an introduction to a larger, in-person trip. Student 1 discussed using a VFT within a preparatory lecture:

> I reckon that would almost be really cool if you could have [a VFT] in a lecture behind [the examiner]. And like [the examiner] stood there with . . . his laser pointer and then it was like moving through before the field trip and he was going, "This is what you can see here, and this is what you can see here," and he was using it in a learning tool in that kind of a manner. (Student 1)

They think the VFT could work as a lecture, where the lecturer would introduce the field sites and provide some direction of what landforms are present in the sites. They describe a somewhat didactic situation, but an in-lecture VFT could be activity or discussion-focussed instead of solely descriptive.

Student 4 suggested VFT introductions could be used to reduce the scheduling impact of a TFT:

> I think when a course has got a field trip scheduled for like not a field trip day and it's quite a lengthy one or one that goes over multiple days… I feel like if that were to be shortened to just one field trip day and then just, an extra little online bit, I feel like that would be the best use of [a VFT]. . . . If you do that you can just tell all the students "Ah, yeah, so in preparation for this field trip, watch this, or read this," and then you can kind of skip all the long introductory stuff that takes like an hour or so at the start and then just get right into the practical work.

In this scenario, a short VFT would provide an introduction to the field sites and activities of the TFT. This could cut the amount of introduction students would need on the TFT, allowing them to dive into practical work and reducing the mental load and time commitment of the TFT.

The geographic accessibility of VFTs led multiple students to suggest ways VFTs could add value to a course in addition to supplementing traditional field work. Student 3 saw how a VFT "could be an advantage for geographical sort of barriers." They elaborated that a VFT would allow case studies of locations in the North Island or overseas:

> Having a virtual field trip could be really good in that sense, or even like overseas things, you know it could, um, bring that closer and you could sort of… where opposed to traveling, which is just sort of, that's not really logistical. (Student 3)

As Student 3 pointed out, it is not feasible to visit locations that are too far away. A VFT is one way to approach teaching and learning about distant or inaccessible locations. Student 2

suggested using VFTs as part of the laboratory program of a course, in addition to running local TFTs:

> Say you want to do something in the North Island that's too expensive to go up there, you can make a virtual one. . . . You could even like, show different features like from overseas like different events there. Could be a lab replacement. (Student 2)

VFTs could be incorporated into the laboratory curriculum to show curated examples of course content. They could be case studies of particular locations or subjects and include interactive activities exploring landscapes that the class would not otherwise be able to visit.

Students' insights to the use of VFTs to supplement TFTs, replace them when necessary, and add value to course curriculum match the best-use practices argued in the literature. Many other educators conclude that VFTs work best as supplements to, rather than substitutions of, in-person trips (Cliffe, 2017). Throughout the literature, students and instructors overall report a preference for TFTs over VFTs to the same locations (e.g., Friess et al., 2016; Pugsley et al., 2022) and think they should not replace TFTs (Bond & Cawood, 2021; Seifan et al., 2019), though simultaneously recognise the flexibility and geographic accessibility of VFTs (Peace et al., 2021; Pugsley et al., 2022), and the benefit and potential of multi-scalar resources and observations (Bond & Cawood, 2021; Watson et al., 2023).

5.4.3 The future of the SOSC223 VFT

The examiner and I intend to improve and use the SOSC223 VFT as a complement to the TFTs to Kaitōrete Spit and the Rakaia River in future years. In his interview, the examiner outlined his ideas to refine and better-incorporate the trip into SOSC223:

> I almost wonder if there could be two versions of it. Where one's the prelude . . . It's got the backbone of it there, so the geographic element of it's emphasized. The students know where they're going, they know the sorts of things they're going to [learn] about. "Here, we're going to be talking about the, the history of this part of the landscape over what sort of timescale," and then something about processes . . . So you've got some idea what the sorts of things you're going to have to be thinking about in the field. (Examiner)

We would design two different versions of the VFT. In the above quote the examiner describes a prelude that would introduce students to the regional and site-specific geography, the types of activities they'll do, and the content or concepts they'll focus on at each site. It could contain exercises and content to situate lecture knowledge into the

relevant local geographic context, with questions “directing [students] rather than testing them” (Examiner).

The second version would be a “full-blown version . . . that could be the stand-in for those who couldn't go, or as somewhat of a recapitulation on what was done [in the field]. . . . It will consolidate and provide additionality” (Examiner). Instead of closely mimicking the structure of the TFTs, it would lean into identified potential strengths of VFTs. It could “consolidate and provide additionality” to the TFTs by highlighting the regional geography and geologic setting. Sites could be chosen specifically to emphasise key landforms, change in the landscape, or key takeaways, rather than being constrained by transportation logistics, as on a TFT. Multimedia at sites could include temporal scale with videos or photos under different conditions, or models or animations illustrating change in the landscape through time. The VFT would provide enough rich context and guidance to be a meaningful replacement experience for students who cannot attend the TFTs, and also consolidate and build upon the in-field experience of the class. Students could use it to refresh and reflect on their TFT experiences, either in their own study or within a classroom debrief.

These are currently rough ideas. Our intent is to modify and integrate the VFT into the existing field trip curriculum. Two versions of the VFT to the Canterbury coast and plains would complement the existing TFTs to Kaitōrete Spit and the Rakaia River. One would supplement the in-person trips by introducing students to the regional geography, the sites they will visit, and the types of content and questions they will explore in the field. The other version would be a substitute of either TFT for any student who cannot attend in-person. This would be intentionally designed towards the strengths of computerised field trips identified in RQ2 and resourced and structured to provide rich, authentic experiences and foster students' connection to the landscape in line with Kolb's experiential learning model.

5.5 Conclusions: A bimodal approach

The plan for future versions of the SOSC223 VFT involves re-designing the course's field trip curriculum to incorporate both traditional and virtual field experiences in a blended, or bimodal approach to field instruction. Despite their weaknesses in, for instance, fostering interpersonal connection, and providing full-body experiences, VFTs can be engaging learning experiences than can introduce and reinforce content and concepts taught elsewhere in the course. Yet despite their strengths in, for example, their flexibility,

repeatability, and ability to facilitate multi-scalar observations and interpretations, VFTs are not suited to replace all aspects of traditional field trips and field work. Instead of taking a "one or the other" attitude, there is potential in taking a bimodal approach to field education where VFTs are used to supplement and augment TFTs or add interactive learning opportunities to other aspects of a course.

Such a blended model to delivering field trips and field work is an emerging conclusion from recent VFT literature. Many VFTs were run throughout Covid lockdowns in place of traditional field trips and field work. Yet even with the challenges of emergency remote teaching, educators frequently report that they intend to build upon and continue to use their lockdown VFTs (e.g., Bond et al., 2022; de Paz-Álvarez et al., 2022; Peace et al., 2021). Instead of dismissing VFTs for their challenges, or advocating for replacing in-person field work with VFTs for their accessibility, educators recommend combining in-person field work with complementary and augmentative VFTs. Bond et al. (2022) assess staff and student perceptions of learning outcomes, support and cohort cohesion resulting from their Covid-19 VFT. While perceptions were frequently negative pre and post trip, the VFT was overall successful at meeting its learning outcomes, and the authors intend to expand and develop the positive aspects of the experience in future blended environments (Bond et al., 2022). Here in Aotearoa NZ, Watson et al. (2023) report that their volcanology VFT was effective at developing students' content knowledge and geologic interpretation, especially through its interactive 3D models and 360* videos, and when these skills were reinforced elsewhere in the curriculum. They conclude VFTs can reinforce classroom learning activities, and can be reinforced by fieldwork (Watson et al., 2023). Whitmeyer and Dordevic (2021) suggest a combination of in-person and virtual field experience may be "the most effective approach for producing a more inclusive and equitable learning environment" (Whitmeyer & Dordevic, 2021, p. 226). The results of this study, describing participants' experiences with the VFT, analysing the strengths and weaknesses of the trip, and discussing how the affordances and drawbacks of the VFT compare to TFTs, provide additional support for a bimodal model of tertiary field education combining virtual and physical field environments.

Chapter 6

Conclusion

Undergraduate earth science education emphasises the role of field trips and field work in student learning and development. Thus, when the Covid-19 pandemic caused teaching to shift online, many educators developed replacement VFTs to deliver the field components of their courses. Although VFTs had become a growing part of earth science curriculum in the years leading up to the pandemic, research on their effectiveness was limited to knowledge testing to quantify learning, ordinal surveys with limited qualitative data to measure basic attitudes and perceptions, and educators' informed but informal reflection on their experiences using VFTs. Prior to Covid-19 and the rapid transition of field trips to online formats there had been little detailed investigation into the experiences of staff and students developing and attending VFTs to provide evidence for practitioners' wisdom and illuminate the context behind and reasons for particular experiences.

Together with contemporary studies exploring VFT education during Covid, this thesis begins to address the research gap. It employs a qualitative case study design using thematic analysis of participant interviews to gain detailed insight into the experiences and perceptions of staff and students involved with the SOSC223 VFT developed and run during Covid lockdown, in order to identify what factors affected participants' experiences, to evaluate the strengths and weaknesses of this particular VFT, and compare these with the affordances and drawbacks of TFTs. By exploring what factors hurt and helped participants' experiences with the SOSC223 VFT, this thesis begins to shift the conversation on whether VFTs can replace or should only supplement traditional field experiences to identifying how VFTs may be used well in overall course design. It supports the thoughtful and intentional implementation of VFTs within earth science curriculum.

Thematic analysis of participants' interview transcripts revealed different overall attitudes between the students and instructors. The course examiner and I had a negative experience creating the StoryMap, due mainly to the limitations of Covid-19 lockdown, and viewed its efficacy through a sense of frustration and ambivalence. Students were apprehensive at the outset of the VFT and wondered how a computer activity could replace field experience. This tension was tempered by their appreciation for having some sort of field trip during

lockdown, and some were curious about how we might show spatial information or build a sense of the landscape into the VFT. Although most students would have preferred attending a TFT, they felt the VFT benefitted their learning, though all but one student remembered considerably more from the first half of the trip compared to the second. Overall, students reported a mix of enjoyment and frustration from different aspects of the VFT.

The factors associated with students' learning and enjoyment included whether they experienced technical issues, the repetition and alignment of content elsewhere in the curriculum, individuals' personal interest, and interpersonal connection. These factors informed the analysis of the strengths and weaknesses of the VFT as an educational experience. The weaknesses of the VFT included its lack of easy interpersonal interaction, its reliance on technology like fast computers and stable internet, and the resourcing requirements to integrate multimedia and scaffold the content of the trip. Despite these challenges, the flexibility and repeatability of the VFT benefitted all participants, and the trip demonstrated clear potential for well-designed interactive multimedia to facilitate students' visual connection to place and ability to visualise complex processes.

The SOSC223 VFT differed from TFTs in the logistical constraints and affordances and how the mode of delivery impacted students' social and physical immersion within the learning experience. In field education, students' physical and social engagement form memorable events, deepen learning and enjoyment, and build identity within the discipline. Earth science field education often refers to situated learning, experiential learning, and cognitive embodiment as relevant theoretical frameworks for field learning, where students' physical and social engagement form memorable events, deepen learning and enjoyment, and build identity within the discipline. The VFT lacked the same engagement due to the weaknesses identified; its overall design lacked the coherence to reliably foster social and geographic connection. However, the strengths of the VFT regarding the flexibility and repeatability of the computerised mode would be difficult to achieve under the time and logistical constraints of a TFT. Its asynchronicity aided students by providing them with autonomy to fit the trip within their workloads, take breaks, and reflect on and review their understanding in a way that is difficult to achieve in a time-limited TFT. Additionally, the ability of the VFT to display a variety of non-observable digital data, include interactive models of the landscape, and illustrate change through time provided context-rich

opportunities for students to connect with the VFT in a way that complements the field skills and understandings students might gain on a physical field trip.

Through conducting this research, it became clear that VFTs can add value to course design when thoroughly resourced and thoughtfully integrated. The plan for future versions of the SOSC223 VFT involves re-designing the course's field trip curriculum to incorporate both traditional and virtual field experiences in a blended, or bimodal approach to field instruction. Rather than taking a “one or the other” attitude to the use of VFTs in field education, there is potential in taking an integrative approach where VFTs are used both to supplement and augment TFTs and additionally used as standalone activities to add interactive learning opportunities to other aspects of a course. Regardless of how they are applied, VFTs should be designed in a way that builds on their flexibility and repeatability, minimises the impact of their lack of sociality, and builds visual connection through well-resourced, well-integrated multimedia.

6.1 Limitations

The data in this study provided a rich overview of participants' experiences with the SOSC223 VFT but lacked saturation and depth. This was due to three main challenges - Covid lockdown, my lack of experience conducting qualitative research, and a small sample size. Case study methodology tries to use many types of qualitative data to maximise triangulation to increase the validity and reliability of the study (Merriam & Tisdell, 2015). In this study I was able to triangulate by eliciting the experiences of both staff and students and using interviews in combination with my own reflective journaling. However, due to the logistical, time, and workload pressures of lockdown on everyone, I was unable to conduct formal observations of students working on the VFT and could not, for example, assign students with reflective writing prompts to further triangulate the data and analysis. Additionally, I was unable to conduct follow-up interviews or seek feedback from the student participants to check my preliminary interpretations against their intended meaning, as I could with the course examiner. The depth of students' responses within the interviews was hindered by my inexperience conducting interviews. The interview guide I designed was overly-structured and initially I did not have the experience to comfortably deviate from the questions on the list. I was not responsive enough to follow up on interesting points students made to gain deeper insight into their experiences, especially in the first few interviews. This improved as I gained more experience and reflected on the previous

interviews and the beginnings of the emergent themes, but a more-experienced researcher would likely have gained richer data from the beginning. Finally, the participant pool in this case study was very small, which limited the range of experiences portrayed and analysed. There were only eight potential student participants - five of whom volunteered to participate, and the only staff involved with the VFT were the examiner and myself. Other students may have had different experiences than those interviewed, and other important themes may have emerged from a larger, or different, sample.

The types and strength of conclusions are further limited by the nature and aims of this thesis. I did not set out to measure what learning occurred on the VFT, to determine every possible phenomenon that may have affected participants' experiences or learning on the trip, prove causal relationships, or to quantify the impact of individual factors that emerged from the data. Instead I have tried to provide a rich overview of the examiner and my experience developing and delivering the VFT during lockdown and students' experience with and perceptions of the trip, to identify some factors that affected our experiences and identify the strengths and weaknesses of the trip. I discuss these results in comparison to the benefits of TFTs as identified in the literature and valued by participants in this study. This critical reflection looks at how our trip compared to TFTs in their effects relating to the flexibility of their structure, physical immersion, and social presence. The categories are grounded in the data presented in this thesis and supported by theoretical frameworks applied in field education, but are not necessarily the only important or relevant facets of field education or VFTs. Thus, the analytic results explored in Chapter 5.3 provide supporting, not definitive, evidence towards the importance of community, expert guidance, and connection to content and place in providing authentic, memorable, and positive learning experiences, and suggest that a VFT designed to enhance these elements would result in a better experience than ours could be. The resulting conclusions - that VFTs have strong potential as standalone education activities, and especially if designed to complement and augment traditional fieldwork - add to the growing body of practitioners' wisdom and experimental evidence toward the use of VFTs in earth science education.

6.2 Future research

There are many areas to further investigate within VFT and field education, especially using qualitative or mixed methodologies. Additional qualitative case studies with larger participant samples could add further insight into what factors affect student experience and

learning on VFTs. Studies might then investigate the effect of individual factors on valued outcomes of field education, including but not limited to student learning, skill development, sense of identity, or connection to the landscape. Alternatively, future research could explore teaching or design methods that build on VFT strengths or mitigate weaknesses. For instance, a study could focus on ways to develop exercises or VFT formats that are technologically accessible and fully-functional even with limited internet access.

The impact of using a VFT as preparation for or to augment a TFT is understudied. Though many authors state that this is the best-use for a VFT and intend to do so, there are very few studies using a VFT as preparation for a TFT. The examples that do exist are mixed-method studies relying on pre/post surveys; there are no rigorous qualitative studies or quantitative studies using a control. Research focussed on the impact or experience using VFTs to prepare for TFTs would test the literature's (and my own) assertions on the benefits of VFTs used to augment traditional field work.

In section 5.3 I discussed the relevance of Experiential Learning and embodiment and Situated Learning Theory to the goals of traditional field education and these theories' potential application in a VFT. A key avenue for research is to actually design a VFT aligned with one of these learning theories. The learning theory could then form the theoretical framework for the investigation, where the research would design a way to test the success of pedagogical alignment of the VFT and quantify the learning or other relevant measures of success of students attending the trip. A mixed-method evaluation could involve quantifying knowledge gain or other relevant outcome through pre/post testing and surveying, and qualifying the experience and outcomes through observation of how students engage with the trip combined with, for example, thematic analysis of interviews, reflective journaling, and assignments. By investigating the applicability of discipline-relevant theory to VFTs, future research could gain insight into if, when, and how pedagogically-aligned VFTs in earth science curriculum can foster student knowledge gain, skill, and identity within the discipline.

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Appendix A

Ethics Documentation

Human ethics committee approval letter

Research Management Office

T 64 3 423 0817
PO Box 85084, Lincoln University
Lincoln 7647, Christchurch
New Zealand
www.lincoln.ac.nz

27 July 2020

Application No: 2020-32

Title: The efficacy of on-line delivery for practical-based learning in the geosciences

Applicant: L Hall

The Lincoln University Human Ethics Committee has reviewed the above noted application.
Thank you for your response to the questions which were forwarded to you on the Committee's behalf.

I am satisfied on the Committee's behalf that the issues of concern have been satisfactorily addressed. I am pleased to give final approval to your project.

Please note that this approval is valid for three years from today's date at which time you will need to reapply for renewal.

Once your field work has finished can you please advise the Human Ethics Secretary, Alison Hind, and confirm that you have complied with the terms of the ethical approval.

May I, on behalf of the Committee, wish you success in your research.

Yours sincerely

Grant Tavinor
Chair, Human Ethics Committee

PLEASE NOTE: The Human Ethics Committee has an audit process in place for applications. Please see 7.3 of the Human Ethics Committee Operating Procedures (ACHE) in the Lincoln University Policies and Procedures Manual for more information.

Note: The above application approval was for the original research plan before the field trips were cancelled due to Covid-19 lockdown. The post-lockdown updated project used the same application number with a new title, research information sheet and interview guide. It was re-approved by the HEC via email without a formal letter.

Research information sheet and consent form – Student participants

Lincoln University

Department of Soil and Physical Sciences

Research Information Sheet

Introduction and invitation
I would like to invite you to participate in a project entitled "Geoscience learning in the field: Examining virtual field trips and the remote experience." Your participation is voluntary and confidential and has no bearing on your assessment in this or future courses.

What is the aim of the project?
This project aims to investigate alternatives to traditional in-person field trips and evaluate student and staff experiences with the replacement virtual field trip in the 200-level course Physical Landscapes: Formation and Function. As a student of SOSC223 in 2021 who completed the virtual trip, you are invited to participate.

What will you be asked to do?
Your participation will involve attending a semi-structured interview with myself over Zoom. The interview will take up to 1 hour. In the interview, you will be asked questions about your perceptions of field-based learning and your experience with the virtual field trip you completed this semester.

Your participation is voluntary and you may decline to answer any interview questions without affecting your ability to participate in the project. At the start of an interview I will request consent to take notes and record the interview. You may choose to decline consent to the digital recording, in which case I will solely write notes.

If you decide to participate, I will contact to you arrange a Zoom meeting for a time that suits your schedule December 2021 or January 2022.

How will my data be used?
The results of these interviews will form a chapter of my master's thesis and may be submitted for publication in academic journals. At the completion of this project, I will email all SOSC223 students from 2021 the research abstract and link to said thesis.

Your feedback will be used to improve SOSC223 laboratory and field trip content. The Department of Soil and Physical Sciences may also use the results to help inform course design as teaching staff at Lincoln University develop more blended learning and online materials and improve emergency remote teaching capabilities.

Your identity will remain private and no identifying information will be published. Interview data will be aggregated via thematic coding, and no published quotes will contain identifying information without specific consent. The identity of any participant will not be made known to any person outside of my supervisory committee and the Human Ethics Committee in the case of an audit. To ensure anonymity, individual participant notes will be seen only by me and will be stored electronically with password protection.

What if I have questions or wish to withdraw?
If you decide to withdraw from the project, including withdrawing any information you have provided, you may do so at any time up to April 8th 2022. You can do this by contacting me (Louisa Hall) or my main supervisor (Carol Smith) using the contact details below. You can also contact one of us if you have any questions or concerns about this project; we would be happy to discuss with you.

Researcher: Louisa Hall, Master of Applied Science student and tutor, Department of Soil and Physical Sciences
[redacted]

Main supervisor: Dr. Carol Smith, Department of Soil and Physical Sciences
[redacted]

Assistant supervisor: Dr. Jerry Maroulis, Centre for Learning and Teaching
[redacted]

Assistant supervisor: Dr. Peter Almond, Department of Soil and Physical Sciences
[redacted]

What will happen next?
If you wish to participate in this study, please sign and email me the consent form below by Monday December 20th, 2021. You may sign electronically or print, sign, and scan your consent form.

I will then follow up with you by email to arrange a date and time for the up to 1 hour interview. To reimburse you for your time, participants will receive a $20 voucher.

Consent

1. I have read and understood the description of the project above.

2. I have been given sufficient time to consider whether to participate in the project and to ask questions.

3. I have saved a copy of this Research Information and Consent Form to keep.

4. I understand that I may withdraw from the project, including withdrawal of any information I have provided, up until April 8th 2022.

- ☐ **I consent to participate in the project.**
- ☐ **I consent to publication of the results (which may include my anonymised information).**
- ☐ **I consent to having an audio or video recording made of my interview. OR**
- ☐ **I do not consent to having an audio or video recording made of my interview, but agree to notes being made.**

_____
Name

_____
Signed

_____
Date

If you wish to participate in this study, please fill complete the consent form and return it to me by email at [redacted] Please save a copy of your signed form for your records.

Research information sheet and consent form – Instructor participants

Lincoln University

Department of Soil and Physical Sciences

Research Information Sheet

I invite you to participate in a project entitled "Geoscience learning in the field: Examining virtual field trips and the remote experience."

This project aims to investigate alternatives to traditional face-to-face (F2F) field trips and evaluate student and staff experiences with the replacement virtual field trip (VFT) in the 200-level course Physical Landscapes: Formation and Function. As the examiner of SOSC223 in 2021 who developed the virtual trip, you are invited to participate.

Your participation will involve attending a semi-structured interview with myself in person or over Zoom. The interview will take up to 1 hour. In the interview, you will be asked questions about your perceptions of field trips, your intentions with the trips in SOSC223, and your experience developing and delivering the replacement VFT in semester 2 2021.

Your participation is voluntary and you may decline to answer any interview questions without affecting your ability to participate in the project. At the start of an interview I will request consent to take notes and record the interview. You may choose to decline consent to the digital recording, in which case I will solely write notes.

The results of this interview will be included within a chapter of my master's thesis and may be submitted for publication in academic journals. You may be identifiable through your role as sole course Examiner of SOSC223. However, any identifiable information will only be published with your express consent, and you will have the opportunity to check phrasing and quotes.

If you have any queries or concerns, please contact me. If you wish to participate in this study, please fill complete the consent form and return it to me by email at [redacted] I will then contact you to schedule an interview time.

Consent

1. I have read and understood the description of the project above.
2. I understand what is required of my participation.
3. I have saved a copy of this Research Information and Consent Form to keep.

☐ **I consent to participate in the project.**

☐ **I consent to having an audio or video recording made of my interview. OR**

☐ **I do not consent to having an audio or video recording made of my interview, but agree to notes being made.**

_____

Name

_____

Signed

_____

Date

Appendix B

Interview Question Guide

Student participants

Page 1/2

Project title: Geoscience learning in the field: Examining virtual field trips and the remote experience

Project brief:

The current global pandemic has necessitated a change in how institutions approach teaching. While the impact of Covid-19 in Aotearoa New Zealand has been less severe than for many other countries, there has been disruption to face-to-face (F2F) teaching, especially of hands-on experiences like field trips.

In August 2021, the nationwide lockdown meant we had to cancel two of the three field trips in the course SOSC223 Physical Landscapes: Formation and Function. We adapted by developing an ad hoc virtual field trip (VFT) aiming to provide student with as close an experience to their missed F2F trips as manageable.

The ability to develop and deliver effective online activities is of increasing importance, and we wish to learn from our experience this semester. This leads to the question: How does the VFT that we developed for SOSC223 compare to a F2F field trip?

One way we seek to address this is through student interviews assessing the following questions:

1. What are students' perceptions of field trips in general?
2. How did the VFT meet student expectations?
3. How did students engage with the VFT?
4. What are students' perceptions of the VFT?
5. How effectively did the VFT meet intended learning outcomes?

Interview guide:

Student background data:

- What is your major?
- Why did you choose this major?
- What year were you last semester?
- How comfortable are you working in an online learning environment?
- Are there any obstacles to your full online engagement?

Assessing student perception of field trips in general:

- What do you like most about field trips?
- What do you like least about field trips?
- How well do you think field trip experiences enhance your understanding in a course?
- Please describe an ideal field trip. Number of people, types of activities, work alone or in groups…
- How did you feel when your F2F field trips to Birdlings Flat and Rakaia were cancelled?

Assessing student expectations:

- Before commencing your VFT, did you feel a VFT could be an effective replacement for a F2F trip? Why?
- What did you expect from the VFT before starting?
- How did it meet/not meet your expectations?

Assessing student engagement with the VFT:

- Please describe in detail what you did on the VFT.

How much time did you spend on the VFT?
What types of activities were most engaging?
What types of activities were least engaging?

Assessing student perceptions of the VFT:
What did you like most about the VFT?
What did you like least about the VFT?
What would you change about the VFT?

Assessing learning outcomes:
Did you have any technical issues working on the VFT?
What do you think was the purpose of the VFT?
What did you learn from the VFT?
Were there things that helped in your understanding of how these landscapes formed?
Were there things that seemed confusing or lacking in context?

Overview questions:
Did your experience with the VFT influence how you approached our F2F field trip to North Canterbury? (For those who attended the F2F trip)
How did the VFT and F2F field trip compare? (For those who attended the F2F, otherwise)
How did the VFT compare with past F2F field trip experiences?
How are VFTs best used in a course?
Are there other remote field-based activities that would be useful?
What could we have done differently?
Do you have any other questions or comments?

Instructor participants

Project title: Geoscience learning in the field: Examining virtual field trips and the remote experience

Project brief:

The current global pandemic has necessitated a change in how institutions approach teaching. While the impact of Covid-19 in Aotearoa New Zealand has been less severe than for many other countries, there has been disruption to face-to-face (F2F) teaching, especially of hands-on experiences like field trips.

In August 2021, the nationwide lockdown meant the teaching staff involved in SOSC223 Physical Landscapes: Formation and Function had to cancel two of the three field trips in the course. We adapted by developing an ad hoc virtual field trip (VFT) aiming to provide students with as close an experience to their missed F2F trips as manageable.

The ability to develop and deliver effective online activities is of increasing importance, and we wish to learn from our experience. This leads to the question: How does the VFT that we developed for SOSC223 compare to a F2F field trip?

One way we seek to address this is through an interview with the course Examiner to assess the following questions:

1. What are the instructor's general perceptions of field trips?
2. What are the instructor's intentions with the specific field trips?
3. What was the instructor's experience developing the VFT?
4. How successful was the implementation of the VFT to student engagement and learning?
5. What are the instructor's final takeaways?

Interview guide:

Instructor background data:

What is your field of interest?
How long have you taught SOSC223?
How long have you led field trips?
What previous exposure have you had to remotely delivered field exercises?

Assessing instructor general perception of field trips:

Do field trips provide a valuable experience? Why?
What have been your biggest challenges with facilitating field trips?
How do you think your students value field experiences?
Please describe an ideal field trip.
Please describe your teaching style while in the field.

Assessing instructor intention with the specific field trips:

What is the intended purpose of the field trips to Kaitorete Spit and Rakaia?
How are the trips designed to meet this (/these) purpose(s)?
Why did you choose to replace these field trips with a VFT using Story Maps?

Assessing instructor experience developing the VFT:

What time and resources did developing the VFT involve?
What were your goals when designing the exercises?
How were you able to port your teaching style in the field – [short summary of participant response] – to the virtual space?

Assessing perceived success:

- Did student engagement match your expectations?
- What exercises did/did not work well?
- What content did students struggle with?
- In what ways do you think the VFT was successful?
- How would you improve the VFT?

Final reflection questions:

- Do VFTs have a place within the course? If so, how could they be best utilised?
- Are there remote learning activities, beyond the Story Map model, that you'd like to try in the future?
- Do you have any other comments?