Opportunities for learning mathematics in a newly established Innovative Learning Environment (ILE).

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Abstract

There is currently an increasing movement towards the implementation of Innovative Learning Environments (ILEs) in primary schools across New Zealand, advocated by the Ministry of Education. This ILE implementation has been met with both support and opposition from the public and educators alike. Simultaneously, mathematics education in New Zealand is undergoing reform, with research informing changes from traditional transmission-style approaches to those that place students at the centre and promote mathematical understandings in communities of learning. Reforms in how students learn mathematics are well-aligned to the skill sets promoted as reflecting the competencies required of 21st century learners. However, the paucity of research into opportunities for students learning mathematics in ILEs warrants the need for further research.

Using a qualitative methodology and single case study design, this research explored the opportunities afforded to Year 7 and Year 8 students when learning mathematics in a newly established ILE. Throughout Term 2, 2018, data collected from one-to-one teacher interviews, classroom observations, and student focus group discussions were coded, analysed, and triangulated. Four salient themes emerged from the data: the affordances of spatial arrangement, opportunities for student agency, students leading the learning, and the ILE as a mathematics community of learners. Teacher and student participants reported space within the ILE opened opportunities for individual and collaborative mathematics learning. The increased affordance of student voice and choice positioned students as the central drivers in both the leading and learning of mathematics. The open, fluid, and flexible spaces within the ILE presented increased opportunities for varied grouping structures. When combined with new co-planning and teaching arrangements, teachers and students considered that opportunities to learn involved greater options for mathematical challenge and multiple perspectives on mathematics.

This research study presents mathematics learning within an ILE through the voices of the participants, particularly the student participants. It provides insights into the set up and spatial qualities afforded within the ILE, ways students described their mathematical learning opportunities, and comparisons they made to their previous single-space learning environments. Teacher and student participants in this research were very supportive of the ILE arrangement and the opportunities for learning mathematics that it afforded.

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Chapter 1: Introduction

Picture a mathematics classroom. For some people, images of individual forward-facing desks with students silently working through closed questions from a text book may be evoked. For others, images of students collaboratively solving open-ended problems, asking questions, and presenting explanations may be envisaged. Perhaps the settings are merged with features of each context imagined.

Recent national and international studies in mathematics education have advocated for reforms to the way children learn mathematics that go beyond traditional transmission-style teaching. Their research studies highlight the opportunities for students' learning mathematics in communities of inquiry through collaboration, explanation, and justification (for example, Hunter & Anthony, 2011; Staples, 2008; Walshaw & Anthony, 2008). In these communities, mathematical understandings are negotiated through the participatory norms underlying the cultural and social setting within the classroom (Hunter & Anthony, 2011).

These reforms, which underpin understandings of how students learn mathematics, are also central to skill sets promoted as reflecting the competencies required of 21st century learners (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2016). Termed the four C's—creativity, critical thinking, communication, and collaboration (Partnership for 21st Century Learning (P21), 2007)—these competencies are associated with concepts of personalisation, connections to the real world, innovation, and flexible grouping structures (Organisation for Economic Cooperation and Development (OECD), 2003). Situated in a context of 21st century digital technologies (Benade, 2017a), knowledge is no longer considered a "sealed system" (p. 26) but does instead act as a catalyst, presenting opportunities for new imaginings and possibilities. These new concepts of knowledge and learning are also evident in changing classroom design, ways of thinking, speaking, and the types of tools used to facilitate learning (Benade, 2017a). As such, changing school and classroom contexts have further influenced the phenomenon of 21st century learning.

The introduction of Modern Learning Environments (MLEs)—more recently termed Innovative Learning Environments (ILEs)—into schools across New Zealand is designed to create new educational learning spaces that better match 21st century learning. Influencing these changes has been international research conducted by the OECD (2012) into the creation of key principles underlying ILEs. For instance, the OECD (2012) suggests ILEs promote "horizontal connectedness" (p. 7) by putting learners at the centre and encourage integration and application of new learning across contexts. Importantly, it says, these environments support students to become "self-directed, lifelong learners" (OECD, 2012, p. 8) through persistence, communication, and creativity (OECD, 2012). As such, the new spatial arrangements of ILEs are designed to disrupt the concepts of power associated with traditional classrooms where forward-facing rows of desks promoted the front of the room as the space from where teaching occurred (Benade, 2017a). Subsequent drivers for ILE implementation are associated with physical aspects—the creation, replacement or renovation of buildings, and pedagogical characteristics—the encompassing of modern learning and collaborative practices for 21st century learning (Crow, 2015). Indeed, as advanced digital technologies and global competition prompt pressure for educational reform (OECD, 2015), phrases, such as "twenty-first century education" and "future focused" (Abbiss, 2013, p. 6) have emerged, presenting to the public a view of education as being flexible and responsive to global change (Abbiss, 2013).

Drawing upon this OECD research, the New Zealand Ministry of Education has invested significantly in the introduction of ILEs. In these environments, multiple teachers and large numbers of students teach and learn in central areas or "hubs" that incorporate break out spaces for various activities, including group work, presentations, and access to technology (Osborne, 2013). ILEs are also promoted as providing teacher opportunity for pedagogical collaboration, and opportunities for observation and reflection, leading to positive changes in practice (pedagogical adaption); (Hall, 2013) and enhanced student learning opportunities. ILEs have more glass, less walls, and present opportunities for increasingly varied interactions between teachers, learners, and the environment. The aim is that ILEs will foster student independence and social interactions in combination with variety in grouping structures and interrelations with spatial elements.

In mathematics education, researchers have also advocated for reforms supporting effective student interactions, including those that incorporate powerful sense-making opportunities within mathematics learning communities (Yeh, Ellis, & Hurtado 2017). These communities promote collective and individual responsibility, and align with the seven principles of learning (OECD, 2012), which position students as central to the learning process, place importance on their social interactions, and encourage learning environments where challenge is inherently embedded. For example, Boaler (2016) outlines how classroom norms that emphasise depth over speed, student persistence and struggle, and reposition students' mistakes as opportunities to learn present more varied and complex learning opportunities. She attests to the beauty underlying mathematics that when extended to students, provides access to deep mathematical connections, the result of which may promote more meaningful mathematical relationships. Such experiences, she argues, have significant and long-lasting impacts on students' perceptions of themselves as learners of mathematics. Thus, mathematical communities of inquiry present opportunities for students to become independent learners of mathematics through interconnections between self and environment (Barab et al., 1999; Gresalfi, Barnes, & Cross, 2012) and by making connections to previous learning through the justification of mathematical ideas to other students. In this sense, Boaler and Greeno (2000) suggest that the classroom is a complex ecosystem of interactions with the environment (for example, mathematics tasks and activities) and interactions with people (for example, other students).

1.1 Significance of the Problem

In this, the second decade of the 21st century, we have arrived at a crossroads where traditional classroom environments and pedagogies meet, merge, and potentially clash with educational reform. As a result, questions surround these new educational initiatives: How do ILEs support reforms in mathematics? What affordance opportunities and potential constraints are presented to students' learning mathematics in ILEs? Indeed, recent discussions have arisen about whether the philosophies that underlie ILEs implementation and their connection to student learning are even new. For example, Benade, Gardner, Teschers, and Gibbons (2014) maintain that key differences in teaching and learning this century are associated with accessibility to technology, and concepts of empowering students and democratisation of learning processes are not that different to aspects presented by critical thinkers of the twentieth century (for example, Dewey, Freire, & Illich).

Murphy (2016) suggests that although studies have researched ILE connections to 21st century learning, much of this research is from a philosophical stance and not based on empirical data. Moreover, the long-term impacts of ILEs on teaching and learning are unknown and may only become apparent over time and upon reflection (Abbiss, 2015). Indeed, the lack of empirical data pertaining to ILEs continues to encourage educational debate.

It is also important to highlight that what is not yet well understood when learning mathematics in an ILE are the experiences of the students. Understanding their perceived experiences is important because given the financial investment into ILE implementation, greater numbers of New Zealand students will be learning within these environments. Furthermore, it is of value to listen to, evaluate, and understand the lived experiences through the voices of the students within these environments. The need for additional research is supported by Bradbeer et al. (2017), who argue the large financial investment in ILEs in New Zealand justifies the need for further research to ensure future decisions involving learning spaces are supported by evidence.

Therefore, although scholarly arguments present benefits of ILEs and, similarly, there is research outlining best practice in the teaching and learning of mathematics, there is limited research exploring opportunities afforded to students when learning mathematics in an ILE. Furthermore, few studies explore opportunities (and potential constraints) from the perspectives of the students.

1.2 Case Study: Mathematics Learning in a Newly Established Innovative Learning Environment

The purpose of this case study was to explore the opportunities afforded to students when learning mathematics in a newly established Year 7 and Year 8 ILE. For this study, the term "affordances" means "the perceived and actual attributes (Gibson, 1977) and functional properties (Pea, 1993) that can be used to facilitate student learning" (as cited in Imms, Mahat, Byers, & Murphy, 2017, p. 14).

This study addresses the following overarching exploratory research question and sub-questions:

What can be learned about the mathematical opportunities afforded to Year 7 and Year 8 students in a newly established ILE?

- How do teachers set up the ILE to promote opportunities to learn in mathematics?
- How do the Year 7 and Year 8 students describe their opportunities to learn mathematics?
- How do the Year 7 and Year 8 students compare their mathematics learning opportunities in the ILE to that of a single-space environment?
- How are spatial elements used to support the learning of mathematics?

The case study research reported here was conducted in a medium-sized, full primary school (Years 1–8) in New Zealand. At the time of this study, the school had a stable roll of approximately 330 students. In 2015, prompted by roll growth and directives from the Ministry of Education, the school began planning for the implementation of its first ILE. Alongside this ILE implementation was a commitment from school leadership and the Board of Trustees to promote collaborative practices across year groups, inclusive of those teachers and classes still within single-space classes. In recent years, the school staff has worked towards committing to an open, supportive, collaborative community with a focus on best practice for teaching and learning. For all research participants, 2018 was the first year they had been involved with teaching and learning within an ILE.

As a staff member of the school, I have been involved in job share teaching positions, although more recently my focus has been on accelerating student learning in mathematics (through the Mathematics Support Teacher role). ILEs and their associated 21st century pedagogies ignited my curiosity regarding student opportunities afforded in mathematics within these spaces. I wanted to understand how teachers organised their environment for mathematics learning, and how students perceived and acted upon the opportunities afforded to them.

The following section outlines the thesis organisation.

1.3 Thesis Organisation

Chapter 1 presents current discussions within education circles regarding the implementation of Innovative Learning Environments. It then focuses a lens on mathematics education and how current reforms align with ILE philosophies. Chapter 1 continues by providing justification for the study, its purpose, and the key questions addressed during the research.

Chapter 2 explores and synthesises relevant literature, opening space for this research study. It begins by outlining theoretical perspectives of teaching and learning before giving an historical background to the emergence of ILEs. From here, Chapter 2 discusses opportunities to learn mathematics through lenses of participation, communities of inquiry, and student dispositions. It continues by discussing opportunities afforded to students when given a voice and through access to cognitively demanding tasks.

Chapter 3 outlines and justifies the research methodology used throughout this study. It discusses data collection and analysis methods, the research setting, and study schedule. Chapter 3 presents aspects of the study for ethical consideration, methods for selection of participants, trustworthiness, and triangulation of data.

Chapter 4 summarises the research, presenting the key findings from the teacher interviews, researcher observations, and student focus group interviews through participant quotes and observational field notes.

Chapter 5 identifies and examines four salient themes that emerged from the research findings. The discussion of these themes makes connections to the research questions that underpin this study and relevant literature.

Chapter 6 offers the main conclusions resulting from the research. It presents the implications of this research and outlines areas for further study and exploration.

The following chapter—Chapter 2— reviews the literature on ILEs and reforms in mathematics education. It provides a background from which this research study is built.

Chapter 2: Literature Review

2.1 Introduction

In many New Zealand schools, the face of primary school mathematics education is in a state of change. These changes, driven by the urgent challenge to address systemic participation equity concerns (Hunter et al., 2016), have seen an increased focus on mathematical inquiry and collaborative student learning. For many schools, these changes are taking place alongside classroom reconfiguration, with spaces being opened up to promote shared approaches and address individual student learning requirements (Cardno, Tolmie, & Howse, 2017).

With the intention to promote movement away from traditional single-space classroom design to more flexible, dynamic spaces, these new environments can be reworked to reshape and redefine learning areas, promoting skill sets deemed essential for 21st century learners. Of note is that reforms central to mathematics education, such as communication, problem solving, and creativity (Gravemeijer, et al., 2017), are also at the heart of both 21st century competencies and Innovative Learning Environment (ILE) philosophies.

The purpose of this review is to synthesise current literature, positioning it within the context of this study. First, the review will explore the emergence of new learning spaces and their underlying philosophies before discussing their structures and typologies within a New Zealand context. Second, it will discuss ILEs and their connection to 21st century learning competencies. Third, this review will explore theoretical perspectives in the teaching and learning of mathematics, outlining recent mathematical reforms. Finally, Chapter 2 will examine literature exploring opportunities afforded to students to learn mathematics in classroom settings.

2.2 Innovative Learning Environments (ILEs)

Desired educational outcomes associated with our changing world have prompted movement away from traditional classroom practices that focus on the teacher as the transmitter of information to those that put learners at the centre. Guided by recent social theories of learning, teachers and students are viewed as co-constructors of knowledge, working in learning environments that promote student agency, autonomy, and the social nature of learning (Cardno et al., 2017; Dumont & Istance, 2010). Informed by these changing perspectives, educational designers advocate the need for new learning spaces—ones that serve multiple purposes (Charteris, Smardon, & Page, 2018). With this in mind, re-evaluation of classroom systems, organisation, and design have seen the emergence of new learning environments that connect spaces in ways that disrupt traditionally imposed boundaries and control (Wells, Jackson, & Benade, 2018).

2.2.1 Terminology

Variations in terminology are used to describe the new spaces. For example, Modern Learning Environments (MLEs) is a generic term used to refer to spaces that differ from traditional class designs—spaces that are open, and integrate technologies and variation in furniture designs (Amos, 2013). Innovative Learning Environments (ILEs) encompass notions of collaboration and flexibility, and are responsive to technological and societal change. Flexible Learning Environments (FLEs) comprise the physical environment, including movement of people within and between spaces (Gattey, 2018). In arguing for a preferred term, Smardon, Charteris, and Nelson (2015) claim that the descriptor innovation indicates "[a] shift where one does not stay in one place. To innovate suggests one takes an idea, concept or approach and makes it different and better" (p. 150). The word modern, they claim, evokes fixed ideas of time and place.

The Ministry of Education (MoE, n.d.), has settled on the term ILE, defined as a space "that is capable of evolving and adapting as educational practices evolve and change—thus remaining future focused" (MoE, n.d., para. 2). Designed to promote inquiry, collaboration, and reflection by connecting experience with 21st century skill sets (Organisation for Economic Cooperation and Development (OECD), 2009), ILEs align with the New Zealand Curriculum's (NZC) vision to "develop young people who will be confident, connected, actively involved, lifelong learners" (MoE, 2007, p. 7).

2.2.2 Policies and Principles

Policy directives promoting the introduction of ILEs in New Zealand (for example, MoE, n.d.) draw on recommendations from the OECD's, (2012) Innovative Learning Environments project. This project researched the interconnectedness between teaching, learning, and the classroom environment at environmental, community, and system levels. Its analysis of innovative environments internationally led to the creation of the 7+3 Framework (see Figure 2.1; OECD, 2017), which informed ILE implementation in New Zealand schools. Seven principles for learning make up the central core of the framework:

- P1: Learners are positioned as central to the learning process through activities such as inquiry and collaboration.
- P2: Learning environments are based on the social nature of learning, with emphasis on student co-operation and autonomy.
- P3: Cognitive activities are integrated with student emotions and motivations.
- P4: Individual student needs are addressed and students are encouraged to become actively involved in their learning.
- P5: Classroom programmes provide challenge for all students.
- P6: Assessment and feedback inform future learning.
- P7: Horizontal connections are established, both within and beyond the learning environment.

Within each of these seven principles, learners, educators, content, and resources are connected through a pedagogical core. These, in turn, influence and are influenced by school-wide leadership and partnerships with families, cultural organisations, and businesses that go beyond the school setting (OECD, 2017).

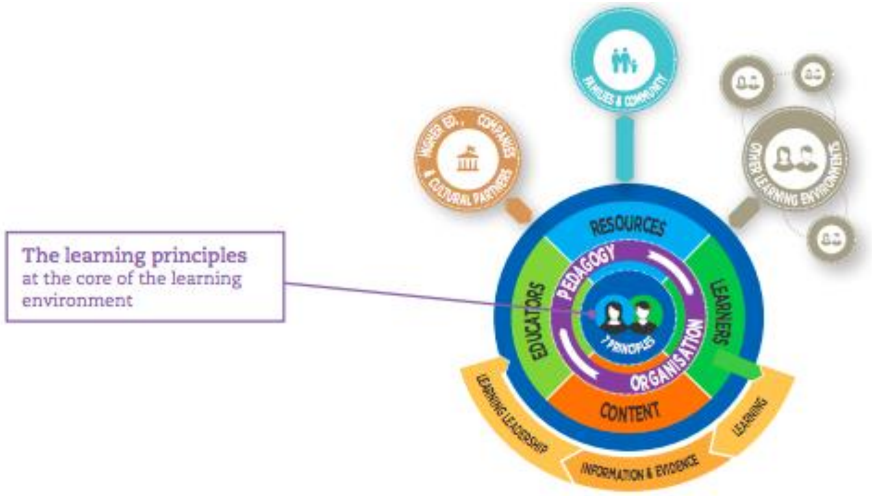

Figure 2.1. The 7+3 Framework.

Reprinted from The OECD Handbook for Innovative Learning Environments, by OECD, 2017, Retrieved from https://doi.org/10.1787/9789264277274-en. Copyright 2018 by OECD. Reprinted with permission (see Appendix O).

2.2.3 Spatial Design

The design of educational spaces influences the types of activities that may occur (MoE, n.d.). Within an ILE, for example, flexibility is achieved by combining or splitting classes for team teaching; openness is achieved through provision of larger spaces with less walls and central areas for teaching and learning; and use of resources is organised through combinations of breakout spaces for multiple activities and technology (Osborne, 2013). Designed to be more than colourful tables and ergonomic chairs, these spaces are multi-faceted in purpose. Here, students no longer have one place (desk) from which to work; instead, “hot desking” (Benade, 2017a, p. 802) affords choice over which space will best meet their learning needs. Likewise, furniture can be reconfigured to create functional learning spaces appropriate for various activities (Benade, 2017a). Shaped by and for the purpose of the learners, Massey (2005) suggests these environments produce interrelations, multiple choices in opportunity, and diversity. In this sense, Sullivan (2012) describes such an environment as “the third teacher” (p. 24).

The environment space, according to Benade (2017a), is socially produced and determines the types of behaviours that occur within. Societies, he suggests, have their own recognisable spaces, interwoven with their culture, language, and identity. Therefore, classrooms (as small communities) produce spatial relations, and space is a product of these interrelations. Tensions may arise in movement from single-space environments to flexible learning environments as one's concepts of space are challenged (Benade, 2017a). Such concepts include "interior spaces"—that is, one's mental and emotional space; "physical spaces"—the changing physical environment; and "social spaces"—redefinitions in concepts of communication and collaboration (Benade, 2017a).

2.2.4 Spatial Typologies

A recent quantitative study (Imms & Byers, 2017) researched three seventh grade classes learning mathematics within three typologies of classroom space: mode one, traditional teacher-centred space; mode two, student-centred space, with collaborative seating arrangements; and mode three, space that merged digital and visual technologies within an informal furniture structure. Each class and their teacher spent one term learning in the contrasting spatial modes, with students completing a survey every three weeks. The study results indicated modes two and three positively impacted on students' enjoyment, attitude, and outcomes in mathematics, contributing to the argument that physical learning arrangements do indeed impact student learning experiences (Imms & Byers, 2017).

The Clever Classrooms, Holistic Evidence and Design (HEAD) project (Barrett, Zhang, Davies, & Barrett, 2015) also researched differences in physical environments and their impact on student learning. Surveying 153 classes from 27 United Kingdom schools over three years, their results showed factors of naturalness, access to individual working spaces, flexibility, and levels of colour had significant impacts on students' learning (see Figure 2.2). In fact, "differences in the physical characteristics of classrooms explain 16 percent of the variation in learning progress over a year" (p. 3), this being comparable to the impact teachers have on students' learning over a year (Barrett et al., 2015).

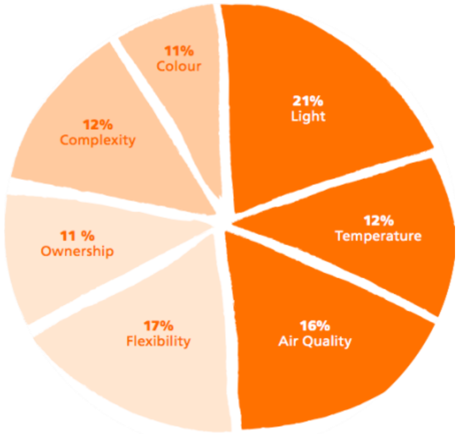

Figure 2.2. Physical characteristics impacting on student learning in reading, writing and mathematics.

Reprinted from Clever Classrooms, HEAD project, by Barrett et al., 2015, Retrieved from https://www.salford.ac.uk/cleverclassrooms/1503-Salford-Uni-Report-DIGITAL.pdf.

For some, ILEs may conjure up images of the 1960s and 1970s when traditional classrooms were opened up to create "open plan" environments catering for multiple classes and teachers. In these spaces, students chose their place, setting their pace for student-centred learning (O'Reilly, 2016). While it was envisaged these spaces would inform changes in teacher pedagogy, without appropriate support, teachers remained resistant to change and, over time, these spaces were reconverted to traditional single-space classrooms (O'Reilly, 2016). However, there is an expectation from some that things will be different this time round.

In contrast to the open plan era, ILE implementation coincides with the ubiquitous access to knowledge and information, increased understandings of how students learn, building and structural innovations, and societal development (Cardno et al., 2017; Knock, 2011). As noted by Leadbeater (2006), while the spatial organisation within ILEs aims to support opportunities for personalised, socially constructed learning, deep personalised learning requires participation in contexts where students are given a voice and ownership over their learning. He suggests that students should be "co-author[s]" (p. 111) of their educational opportunities through goal setting, action, and reflection. This understanding, he maintains, promotes higher levels of engagement and students who are more effective, actively involved learners. Thus, ILEs offer opportunities for learner agency by co-producing identities through ongoing movement and action. Supporters of ILE implementation (for example, Murrihy, 2017) concur, endorsing the larger, agile spaces for the opportunities in flexibility and grouping variation they afford.

ILE introduction has not been without its critics. Those against ILE implementation (for example, King, 2018) maintain that increases in classroom noise due to the large numbers of students interrupt learning, and multiple teachers offer less opportunity for students to form deep relationships with one teacher ("Bigger Classrooms," 2017). Concerns about ILEs also include the adequacy of professional support for teachers. Without adequate professional learning for teachers, it is possible that, in some instances, teachers continue teaching as they would in a single-space classroom (OECD, 2009).

2.3 ILEs in a New Zealand Context

In the 2018/2019 budget, the new Labour-led Government outlined its commitment to ILE continuity, providing an additional NZ$88 million for their implementation (Government of New Zealand, 2018). Three new measures for assessing schools were introduced: the extent to which schools comply with Designing Quality Learning Spaces, Health and Hygiene, and Flexible Learning Spaces.

Designs for ILE spaces are calculated based on teaching space requirement, not student numbers. Each teaching space requirement is approximately 78m² (net) with a 15 percent circulation space, creating an approximate 89m² teaching space (R. Standing, personal communication, June 29, 2018). As such, differing ILE structures are apparent, both within and across schools.

Although ILE implementation is framed around core principles that emphasise individual students with diverse experiences as the central drivers, they are comprised of varying structures and grouping arrangements, including teacher and student numbers, and size of the space. For example, Welcome Bay School in Tauranga was built during the open plan era (1979) with prefabricated classrooms added later. Their journey in implementing ILEs resulted in reclassification of their spaces into three physical ILE models: spaces evolving from the open plan era; spaces being "opened up" by merging two previous classes; and spaces combining three classes into two single-space environments, with another single space utilised as a breakout space (Whyte, House, & Keys, 2016). Contrasting ILE structures are outlined by Benade's (2017b) case study schools: Angelus School has approximately 100 students and three teachers within one of its learning spaces, whereas Innovation Primary's ILEs cater for 40 students and two teachers within each of its learning spaces. The school that is the focus of this study has 38 students and two teachers within its ILE.

In summary, movement away from traditional teaching practices to those that focus on inquiry and collaboration, and putting the learners at the centre has prompted a rethinking of classroom design requirements. The emergence of ILEs—open, flexible spaces, that can be reshaped by and for the learners—in New Zealand primary schools underpins social theories of learning and encompasses competencies viewed as instrumental for 21st century learners.

2.4 ILEs and 21st Century Learning

Twenty-first century learning and knowledge age rhetoric (Abbiss, 2013) are often used in discussions emphasising a need for educational change (Bolstad et al., 2012). Consequently, such phrases may be used to advocate for ILE implementation and to support changes in pedagogical and epistemological perspectives as to what constitutes knowledge.

In contrast to traditional pedagogies where the teacher transmits information, educational reforms involve broader interpretations of knowledge and its function. Bolstad et al. (2012) contend that the term knowledge as applied in this century involves doing and using. As such, knowledge is "more like a verb, than a noun" (p. 4) and involves problem solving, solution finding, and creativity. Learning is no longer about replicating current knowledge; instead, it involves transferring ideas across contexts by connecting and collaborating with others (Bolstad et al., 2012). Mishra and Mehta (2017) suggest knowledge is important on two levels. First, they maintain its importance lies in the understanding of a domain (for example, mathematics) and, second, in its application of skills across areas. Also intertwined within concepts of knowledge utility are intelligence and creativity. In a predictable world, intelligence requires knowledge to direct what is happening, informing where to go next, whereas creativity requires knowledge to build upon skills and concepts when faced with unpredictability (Mishra & Mehta, 2017). Consequently, 21st century learners require more than the acquisition of content knowledge; they need to develop dispositions and competencies that promote exploration of new and complex situations, team work, and flexibility (Bolstad et al., 2012; OECD, 2012).

Research into student knowledge acquisition and learning are not new. Researchers have always explored, theorised, and attempted to explain knowledge and the underlying nature of learning. Dating back to Piaget's research (1936) and the origins of constructivism, we see how learning was promoted as a process of organising knowledge into "schemata" where students moved through stages of development, creating meaning based on their age and environment (McLeod, 2009). Cognitive development promoting the concept of student readiness was visible in education through differentiation where groups of similar skilled students learnt together.

Later, social constructivist theorists advocated the learner as the constructor of meaning, promoting learning as beyond individuals working in isolation. Learning—viewed as socially constructed—occurred firstly through responses to people and the environment (interpsychological) and then through the restructuring of one's existing knowledge to create internal understanding (intrapsychological); McLaren, 2010). Vygotsky (1978) proposes the Zone of Proximal Development (ZPD) where novices complete tasks beyond what they can achieve independently with the support of an expert. He defined the ZPD as: "…the distance between the actual development level determined by individual problem solving and the level of development as determined through problem solving under guidance or in collaboration with more capable peers" (p. 86).

Cultural Historical Activity Theory (CHAT), based on Vygotskian constructivism, connects culture and history, an individual's cognitive understanding, and the interactions and relationships with their environment. Learning is thus shaped by the resources and values of the classroom community and moulded over time by underlying cultural and historical components (Askew, 2012; Foot, 2014). Activities are situated within the learning context, altered through collaboration, explanation, and reasoning by the collective as a whole.

Situated theories argue that learning is actively constructed through participatory practices and influenced by the context in which it is located. These theories present learning as collaborative, embedded within cultural, societal, and historical contexts. Situated theories advocate environments where students are provided with opportunities to inquire into and construct meanings in order to become self-directed, contributing members of a community. The collective support of others through shared negotiation and active construction of meaning (Hunter & Anthony, 2011) requires a more dynamic relationship between the teacher and students.

2.5 The Role of Classroom Context

2.5.1 Ecologies of Participation

Drawing on social theories of learning, it is clear that learning involves the interconnection between the learner and their context, including others in the environment and what is accomplished in relation to the opportunities presented (Gresalfi et al., 2012). Of note for researching ILEs is that classroom contexts have the potential to afford opportunities for action and are realised through powerful interactions between the student (self) and their environment (nonself); Barab et al., 1999).

Classrooms and learning spaces can be viewed as ecosystems where those within are interconnected to their environment (Barab et al., 1999; Boaler & Greeno, 2000; Boylan, 2010). Using ecology as a viewpoint, opportunities for participation afforded within the classroom can be explored. These ecologies are social systems consisting of “figured worlds, positioning, and the space of authoring” (Holland, Lachiotte, Skinner, & Cain, 1998 pp. 271-272). The “figured world” (p. 41) relates to the learning environment, the integration of norms and practices, and the construction of meanings. “Positional identity” (p. 126) refers to the way one understands and enacts one’s role in a social context on a daily basis. The “space of authoring” (p. 170) recognises that people create individual interpretations to make sense of and author their world. Their experiences reflect the possibilities afforded (for example, opportunities for student agency) and how they respond to and within their environment (Holland et al., 1998). Using this framework, learning is viewed as a "trajectory of participation" (Boaler & Greeno, 2000, p. 172) with the way students participate either afforded or constrained by their learning environment through their access to tools, rules, culture, language, and power distribution (Boaler & Greeno, 2000). As such, participation in the classroom ecosystem is multidimensional, informed by classroom expectations, personal identity, dispositions, and pedagogical practices that connect to learning.

2.5.2 Opportunities to Learn Mathematics

Framed within social learning theories, opportunities for students to learn mathematics go beyond knowledge acquisition. Learning is intertwined with who a learner is and the relationship between the individual and the collective. As Askew (2012) noted, mathematics lessons that are not only pre-planned but also integrate student contributions and their emerging ideas promote engagement and opportunities for interactions between both the individual and the group. In terms of mathematical instruction, Gasser (2011) advocates developing student mathematical competencies through presenting problem-solving activities that lead to self-discovered definitions and opportunities to listen to contrasting strategies and solutions. Indeed, in mathematics education there is a strong consensus that effective mathematics learning focuses on students being active constructors of their understanding through exploration, discussion, and reflection, and through forums where mathematical practices of argumentation and justification are encouraged (Smith, Steele, & Raith, 2017).

2.5.3 Communities of Mathematical Inquiry and Classroom Norms

Central to opportunities to learn mathematics in a social framework, reformers advocate that effective mathematics understanding takes place in communities of inquiry where all students have a sense of belonging (Anthony & Walshaw, 2007), are positioned as active participants, and are engaged in understanding concepts presented by their peers (Hunter & Anthony 2011). Students are held individually and collectively accountable. It is through investigation, explanation, and working collaboratively that students build on known concepts, are exposed to sophisticated explanations and extended reasoning, and become more confident, positive, and resilient.

Important in establishing effective communities of learning is the establishment of classroom mathematics norms (Boaler, 2016). These norms influence and shape students' mathematical learning dispositions (Gresalfi, 2009)—that is, their beliefs and values. Dispositions, central to the learning process are embedded in the classroom norms and participatory practices (Hunter & Anthony, 2011) and integrate what a student knows and how they know it, combining their skills to support mathematics learning. For example, Kazemi and Hintz (2014) suggest whole class discussions based on equitable participation and supported by collective classroom norms orient students to focus on key mathematical ideas. Such expectations encourage students to communicate their ideas, take risks, and focus on important peer contributions and mathematical sense-making. As shared by a student: "[w]hen I'm listening to my classmates, I think about how they got their answer. If I don't understand how they got it, I ask them to explain it again" (Kazemi & Hintz, 2014, p. 131).

Likewise, students' mindsets can shape mathematics learning behaviours and influence learning outcomes (Boaler, 2016). Students with growth mindsets believe mistakes are valuable and, through perseverance, they can learn anything (Dweck, 2012). They are keen to receive feedback that can enhance and strengthen understandings. For these students, learning is a priority. Conversely, students with fixed mindsets may avoid challenges, give up easily, and be focused on performance-based feedback that reflects their ability (Dweck, 2012). In fact, classroom norms may present underlying mindset messages where, over time, subtle messages embedded in classroom expectations can impact positively or negatively on student mindsets.

Similarly, the role of persistence and the value of struggle are important in providing students with opportunities for making mathematical connections and meaning (Boaler, 2016). Opportunities for persistence are afforded through challenging tasks that engage students in deep cognitive thinking through variety in strategy use, investigation of solutions, and connection of ideas to prior knowledge (Bass, 2017; Boaler, 2016; Smith & Stein, 2011; Sullivan et al., 2015). Students' persistence is visible in mathematics through their actions when undertaking tasks, including their concentration, application, self-belief, and effort (Clarke, Roche, Cheeseman, & Sullivan, 2014). Flexible use of time (Benade, 2017a) also affords opportunities for delving more deeply into complex tasks. Research suggests students are more likely to persist in classroom environments where time, risk taking, and connections to real life are presented (for example, Clarke et al., 2014).

Further opportunities to engage in mathematics exist in classroom communities through the affordance of student voice. By being given a "voice", students are positioned as active participants (Aguirre, Mayfield-Ingram, & Martin, 2013) who have choices in establishing and directing their learning pathways (Bray & McClaskey, 2013). Nelson (2017a) suggests three orientations of student voice. First, consultation allows insight into the student experience through their voice. Second, participation gives students some ownership and voice over decision-making and third, partnership presents learning as dialogic—that is, through the mutual voices of both teacher and student. Indeed, having a voice gives value to student opinions and ideas, positioning them as capable in directing their learning.

2.5.4 Mathematical Grouping Structures

Variations in grouping structures present contrasting opportunities for students learning mathematics. For many years, English-speaking, Western education systems have typically grouped students according to perceived mathematical ability where ability is assumed to be a "certain amount of intelligence that individuals are thought to possess" (Boaler, 2014, p. 1). Underlying beliefs that ability is fixed can negatively impact upon students' perceptions of themselves as learners of mathematics by attaching an associated status of being in the top or bottom group. Indeed, such views on mathematical grouping structures may be an indication of different cultures' perspectives underpinning the very nature of learning (Boaler, 2014). In a recent New Zealand study, teacher participants reported that ability groups, for the most part, informed mathematical content taught and student engagement and overall mathematics experience (Anthony & Hunter, 2017).

Currently, in New Zealand primary schools, ability grouping is the leading choice of grouping arrangement for mathematics. Recent research (Anthony & Hunter, 2017) shows mixed ability grouping structures were used in just 9 per cent of surveyed classes, being perceived by teachers as time consuming and difficult to implement. Ability groupings connect strongly to "fixed ability and social inequalities" (Anthony & Hunter, 2017, p. 86) whereas heterogeneous groupings promote opportunities for deep understandings based on shared responsibility, effective social interactions, and participation.

2.6 Summary

National and international research, advances in technologies, and redefinitions of learning and knowledge have led to greater understanding of how students learn. These aspects underlie changes in thinking regarding effective pedagogy, which have led to the modernising of 21st century learning environments. For mathematics education, the focus on learning environments that support more equitable opportunities to engage meaningfully with mathematics has largely concerned debates about grouping structures. Moves towards strength-based social grouping have focused on the collaborative and social nature of learning, ambitious teacher pedagogy, and what it means to do mathematics.

This review has highlighted the complex web of potential opportunities and constraints afforded to students when learning mathematics. Mathematical success is multi-faceted and determined through both individual and collective interactions and collaborations within the negotiated norms of their environment. Affordances presented are opportunities for students to recognise, grasp, and merge new concepts with existing skills, attitudes, and dispositions. Reforms in mathematics education and in education in general, frame students as individual learners within a wider collective who will need to develop 21st century skills and dispositions to effectively navigate this knowledge-based technology-driven world.

Currently, in some New Zealand schools, mathematics reforms are accompanied by large financial investments into the building and remodelling of ILEs with continued debate surrounding their impact on student learning outcomes. Advocates for ILE implementation assert the open spaces, use of glass, and multi-purpose furniture promote flexibility, and the variety of teachers promote opportunities for student-centred learning, aligning with skill sets required for 21st century learners. Proponents against their implementation argue they are noisy, inequitable spaces unsupported by empirical evidence where students may get lost among vast student numbers, impacting negatively on their learning.

However, regardless of individual perspectives, what is agreed upon is that students require diverse skills and attitudes to support them as they negotiate a changing world. The 21st century is a global, interconnected community, which presents ongoing challenges as understandings of what constitutes effective teaching and learning continue to evolve. With new challenges, come new possibilities. In order for consensus and shared understandings regarding the role and implementation of ILEs in New Zealand, further research is required into understanding the learning opportunities afforded, student voice and students' perceptions of the ILE experience, and, in the context of this study, on being a learner of mathematics.

Chapter 3: Research Design

3.1 Introduction

Denzin and Lincoln (2018) define qualitative research as being situated in an activity that places the researcher in a context or world. Acting as a frame, the research paradigm sets out beliefs and assumptions that inform how the world is viewed (Wahyuni, 2012). There are two main philosophical lenses through which research is viewed: "ontology" and "epistemology" (Wahyuni, 2012, p. 69). Ontology refers to one's view about the nature of reality whereas epistemology refers to how knowledge is believed to be generated.

In qualitative research, reality (ontology) is assumed to be subjective and socially constructed and knowledge (epistemology) is created through a focus on details and reality of the situation (Wahyuni, 2012). Qualitative researchers seek to integrate both persons and context (Taylor, Bogdan, & DeVault, 2015) and understand the world from the participants' perspectives (Cohen, Manion, & Morrison, 2011). To gain a holistic understanding, qualitative researchers typically explore phenomena within their natural setting, gathering rich narrative descriptions so as to inductively develop insights from patterns within the data (Creswell, 2009; Pope, 2017).

3.2 Interpretive Approach

For this study, an interpretivist approach was taken. Interpretivist researchers seek to understand the experiences and perspectives of those involved, recognising there may be many perspectives of reality as individual participants bring their own experiences to social contexts (Wahyuni, 2012). Interpretivist researchers ask themselves questions like: "[H]ow are events, processes, and activities perceived by participants?" (Ary, Jacobs, Sorenson, & Razavieh, 2010, p. 453). They understand that the experiences participants bring influence their interpretations (see also section 3.4, Researcher Positioning) and, therefore, they cannot be separated from what they "see, hear and understand" (Creswell, 2009, p. 176). An interpretative approach influences the methodology, data collection, and analysis methods used when conducting research.

3.3 Case Study Methodology

For this research, a qualitative case study methodology was chosen. The rationale underlying the choice of case study as methodology was influenced by various factors. First, case studies are appropriate for exploring "processes, activities and events" (Creswell, 2009, p. 177). Second, they align with definitions of a qualitative case study: "an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process or social unit" (Merriam, 1998, p. xiii). Third, the researcher has limited control over the events under study, and, fourth, the study gathers data from a range of sources, allowing triangulation of the evidence to be undertaken (Yin, 2009). Therefore, the interpretivist paradigm, the role of the researcher, and participants all influence the choice of methodology.

Researchers have varying thoughts on what constitutes a case study and, therefore, how it is designed. Yin (2009) suggests four possible case study designs: single or multiple holistic, and single or multiple embedded. Holistic designs, he maintains, have one unit of analysis and are used in analysis of the case as a whole whereas embedded designs have multiple units of analysis and focus on specific parts of the case (Ary et al., 2010). Yin (2003) also outlines three case study types—exploratory, explanatory, and descriptive. Exploratory case studies are used to develop new understandings about the phenomenon of study; explanatory case studies explain complex connections in real life; and descriptive case studies describe events in the context in which they occur. Stake (1995) outlines greater flexibility in his two designs. The intrinsic case study design is used in understanding cases that are uncommon, unusual, or unique whereas the instrumental case study is used to investigate insights and understandings into a specific issue. Merriam (1998) suggests three designs. First, the particularistic design is especially useful for specific situations—including events, circumstances, and experiences (Yazan, 2015). Second, the descriptive design encompasses many variables, resulting in rich descriptions. Third, she suggests the heuristic design, resulting in the reader's increased understanding of the phenomenon.

The purpose of this study, was to explore the opportunities afforded to Year 7 and Year 8 students learning mathematics in a newly established ILE. In order to understand such opportunities, one-to-one teacher interviews, classroom observations, and student focus group interviews were conducted. Thus, for this research, a single case, exploratory, case study method was chosen as the most appropriate (Merriam, 1998; Yin, 2003).

Exploratory case studies connect the research problem, questions, and intent within real-life contexts, combining description and interpretation (Merriam, 1998). Exploratory case studies, descriptive in design, are characterised by the use of “vivid materials” (Merriam, 1998, p. 31), such as quotations and participant interviews, as well as the gathering of data from various sources. Such case studies allow broad exploration of emerging topics, providing a base from which further studies may evolve (Streb, 2010). This case study focuses on contemporary events through direct observations but without manipulation (Yin, 2009).

This case study was bounded by time and place (Merriam, 1998; Miles & Huberman, 1994) within its naturally occurring classroom context. Bounded systems comprise the specific boundaries around the phenomenon of study (the case), including the number of participants and the time frame over which the data is gathered. Embedded within this case study were three units of analysis, those being the perspectives of the teachers, students, and researcher.

3.4 Researcher Positioning

Shaping the lens through which research is viewed is the position of the researcher, informed by aspects including their ethnicity, gender, position of power, and socioeconomic status (Foote & Bartell, 2011). Similarly, the choice of methodology, interview questions, and their associated interpretations are all influenced by the position of the researcher. The researcher is an instrument of data collection (Creswell, 2009; Denzin & Lincoln, 2018; Merriam, 1998), with all data collection and analysis intertwined within their personal understandings, experiences, and perspectives.

Therefore, it is important to address aspects related to researcher positioning and, consequently, outline any possible impacts on the research (Creswell, 2009; Foote & Bartell, 2011). My position in this research has been influenced by my role as a part-time classroom teacher in the school over the past nine years. For six years, I have taught in the senior school in a job-sharing capacity. More recently, I have supported both teachers and students in my part-time role as

Mathematics Support Teacher (MST). During my time at the school, I have also coached many students of varying ages and abilities within a sporting context. In an effort to share and balance teacher-student power differentials and position student participants as influential in the research study (Nelson, 2017b) open, unbiased questions were asked, student articulated experiences and contributions were valued, both the students and the researcher sat together on bean bags, and discussions within the focus group interviews were confidential. Student participants were given opportunities to ask questions and opt out of the research within the first three weeks of the study.

3.5 Research Setting and Participants

The research study took place at a medium-sized, full primary school in New Zealand. The school is a decile nine, with a roll of approximately 330 students.

Participant selection was based on those teachers and students who were learning within the ILE for the 2018 school year. In order to ensure confidentiality, participant teachers were assigned the pseudonyms "Anna" and "Hine." The participant teachers varied in age and experience. Anna has twenty years teaching experience, this being her third year teaching the Year 7/8 level. In contrast, Hine is in her seventh year of teaching, with this also her third year teaching the Year 7/8 level. For both teachers, this year was their first experience of teaching in an ILE.

Student participants were derived from consenting students within the Year 7 and Year 8 ILE. The class comprised of 38 students[1] and included a range of ethnicities: 58% identified as European, 19% as Maori, 13% as Asian, and 5% as Pasifika and South African, respectively. Of the 38 students, 25 consented to being observed and interviewed for the study, a 66% uptake. Within the ILE, teacher reports on student assessment data suggested there was a wide range of students' achievement levels.

[1] Anecdotal evidence suggests that this is a particularly small number of students for an ILE.

The school has made changes to its physical layout in recent years with old buildings moved off site and the addition of a purpose-built ILE. Other classrooms around the school have been "opened up" to create larger learning spaces but without the multiple "break out" space option. For both students and teachers, working within an ILE was a new experience.

3.6 Data Collection Methods

Case study data are defined as "ordinary bits and pieces of information found in the environment" (Merriam, 1998, p. 69) and, in qualitative research, are presented narratively. In this study, I used various qualitative methods to gather data—semi-structured interviews, focus group interviews, and observations. Data were collected throughout May, June, and July, 2018. The following paragraphs address the methods of data collection.

3.6.1 Interviews

According to Punch (2009), interviewing, the most commonly used technique in qualitative research, is effective for gathering participant's perspectives and interpretations of a situation. However, Creswell (2009) points out that they are not without limitations: information received from interviewees is "indirect" (p. 179) and not presented in its naturally occurring context, there is opportunity for researcher bias, and not all participants will be equally eloquent in sharing their ideas. However, despite these limitations, interviews present opportunities to gather in-depth data, allow stories behind participants' experiences to emerge, and can be used to build on previous information collected (McNamara, 1999).

3.6.2 Semi-structured Interviews

Semi-structured interviews allow "individual respondents [to] define the world in unique ways" (Merriam, 1998, p. 74). Semi-structured interviews focus a lens on individual perspectives and experiences related specifically to the research focus. They are based on predetermined questions, which allow for flexibility and promote open-ended answers that can be probed for further detail (Schensul & LeCompte, 2013).

Schensul and LeCompte (2013) suggest that good interview questions: include terms that the participants understand, are short and to the point, and include probing, unbiased questions. In this study, the structure of each interview was framed within a question schedule, using open-ended questions combined with associated probing questions (see Appendix A). Cohen et al. (2011) maintain that throughout the interview the researcher must remain non-judgemental, ensuring any bias or value judgements are concealed. They also suggest that the researcher must consider ways to keep conversation going, encourage participants to share their thoughts and experiences, and address aspects of power.

3.6.3 Focus Group Interviews

Focus group interviews are a useful way of gathering data with their advantages being the time-saving aspect, and the opportunity to listen to groups of people who have worked on similar tasks (Cohen et al., 2011). While responsible for providing the topic and questions, the researcher's role is that of a facilitator, promoting conversations and interactions to flow between the participants (Punch, 2009). Like semi-structured interviews discussed above, focus groups can have disadvantages: One person may command the interview or present views that anger others, and interviewees may be less likely to share their honest opinions or personal views in the presence of others (Cohen et al., 2011). However, when conducted with care to limit these factors, focus group interviews can also present opportunities for interactions that encourage increased dialogue and a willingness of participants to share their "views, perceptions, motives, and reasons" (Punch, 2009, p. 186).

3.6.4 Observations

"Observation is more than just looking" (Cohen et al., 2011, p. 456)—it allows the researcher opportunities to view what is occurring, in context and first hand, resulting in more accurate and legitimate data. Observation takes a number of forms. Structured observation is systematic, with ticks or dashes recorded on pre-planned observation schedules (for example, a five-point rating scale; Cohen et al., 2011), resulting in numerical data. Semi-structured observation is open-ended and focuses on regularly occurring behaviours and patterns (Schensul & Le Compte, 2013) whereas unstructured observation provides a broad overview of the setting. Angrosino (2012) suggests observations progress through phases. Starting with a broad descriptive phase, they move to a focused phase of pattern recognition, to a selective phase where specific observations are purposefully selected. Finally, they reach a point of saturation where the same patterns are repeated. Observational data gathering, however, can have disadvantages. Limitations point to their subjectivity and, consequently, reduced reliability (Merriam, 1998). In addition, observations involving one researcher in social settings (for example, a classroom) may prove difficult given the number of regularly occurring interactions. However, the strength of observation as a data collection method lies in its flexibility, allowing data to be gathered on settings, events, and behaviours. The phases of observations used in this study are captured in the research schedule outlined below.

3.7 Research Schedule

This research study took place over three months (May, June, and July, 2018) and was undertaken in four stages (see Figure 3.1).

Stage One: Exploring the Classroom Environment

In stage one, initial observations were in line with suggestions presented by Taylor et al. (2015) with the researcher playing an unobtrusive role, recording in-depth field notes and descriptions of events within the ILE during mathematics lessons. Natural occurrences that focused a wide-angle lens on the classroom setting were observed. Using a diary, the researcher recorded diagrams of the ILE layout before narrowing the focus to more specific interactions and activities. Personal feelings and understandings of the scene were recorded, with care taken to ensure personal comments were differentiated from descriptive data (Taylor et al., 2015). The initial observations supported the development of more specific questions for semi-structured teacher interviews (see Appendix A).

Stage Two: Teacher Interviews

The second stage, involving teacher interviews, provided insight into understanding the teachers' rationale in organising for mathematics learning in an ILE. Semi-structured teacher interviews were conducted pre and post student data collection, in a quiet space, at a time suitable for teachers. Approximately 30 minutes in duration, each interview began with the researcher outlining its purpose while also aiming to put the participant at ease. Questions were structured, beginning with a broader tour type question moving to more focused questions, a sequence termed "funnelling" (Cohen et al., 2011).

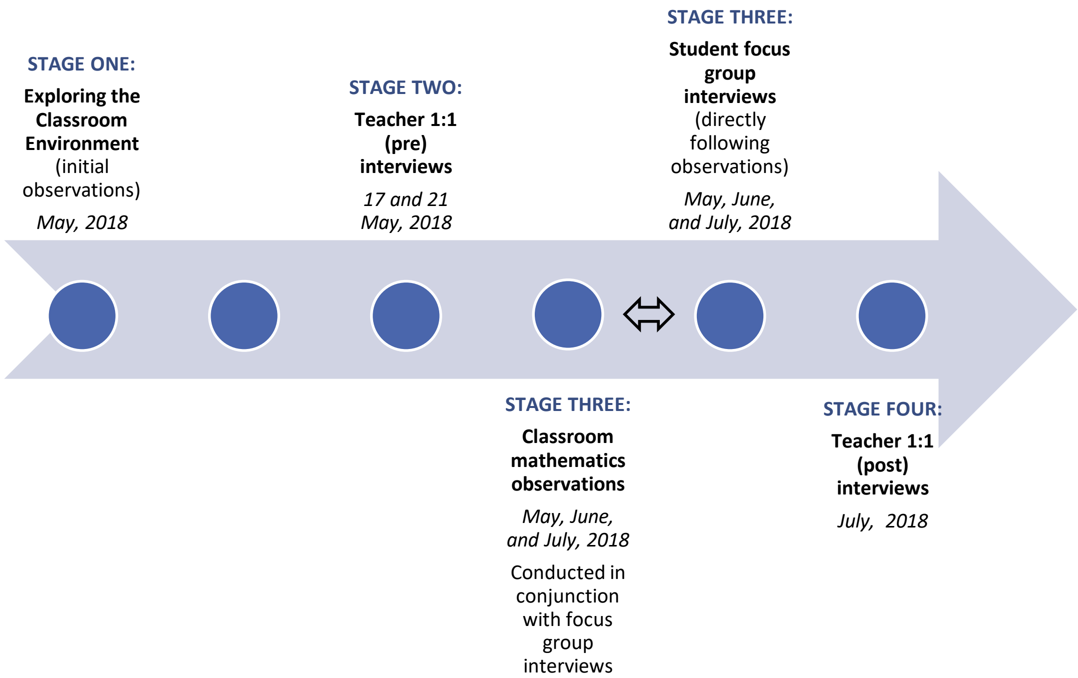

Figure 3.1. Timeline of Data Collection.

Stage Three (Part 1): Classroom Mathematics Observations

Classroom observations focused on student opportunities for learning mathematics. In all, 15 mathematics lessons, each of approximately one and a half hours duration, were observed. This was an iterative process with each lesson observation informing focus group selection and the associated question focus.

Using key ideas from the stage one classroom observations, overarching ideas linked to the study purpose were created. These ideas merged three important aspects of the research. First, research literature on what constitutes student learning opportunities in mathematics was synthesised, suggesting five foci: classroom norms, participation and communication, making mathematical meaning, access to resources, and students at the centre. Second, alongside each focus, possible student actions in their uptake of learning opportunities were recorded. For example, under participation and communication, an action recorded was student involvement in mathematical conversations.

Third, the Effective Teaching and Learning Spatial Framework (Dane, 2016) was integrated within the framework. “The Effective Teaching and Learning Evaluation Tool” (Dane, 2016, p. 221) has previously been used to assess learning environments at universities in Australia. Six important spatial elements deemed essential qualities within new learning spaces—spaciousness, mobility of furniture, furniture variety, access to educational technologies, active surfaces, and student access to the environment (Dane, 2016) —were integrated within the researcher’s observation framework (see Appendix B). The resulting Mathematical Learning Opportunities Observation Framework allowed spatial interactions within the ILE to be observed simultaneously with mathematics learning opportunities and student action. An area for observational comments incorporated into the framework enabled new and unexpected observations to be recorded and added to the observational data set. The observational framework evolved throughout the course of the study, informed by classroom observations and understandings of the mathematical learning opportunities afforded within the ILE.

Observations were followed by focus group discussions with students. Timing the focus group discussions in this way permitted the researcher to use observational data gathered, and focus in on the learning of mathematics in the ILE.

Stage Three (Part 2): Focus Group Interviews

Discussions to gather student voice through a focused discussion that linked to each classroom observation took place in a breakout space as soon as was practically possible following the classroom observations. Involving two to five participant students, the video-recorded interviews explored student experiences and feelings when learning mathematics in relation to:

- classroom norms and expectations;
- access to teachers and students;
- opportunities for participation and communication;
- groupings;
- access to resources and technology;
- opportunities the physical environment lent to learning mathematics within these contexts; and
- access to mathematical activities.

Stage Four: Post Teacher Interviews

Upon completion of the observations and focus group interviews, one-to-one semi-structured interviews were again conducted with the teacher participants. Data were then recorded into matrices, compared across the three data sources, and examined for their convergence, consistency or contradiction (Ary et al., 2010). This triangulation of data, allowed different perspectives to be viewed and, consequently, permitted a deeper understanding of the phenomenon of interest to be gained (Denzin & Lincoln, 2018).

3.8 Data Analysis

Data analysis involves making sense of the data collected. Merriam (1998) outlines this as movement from the concrete or descriptive data gathered to the interpretations, understandings, and findings of the research. By making the analysis explicit, the researcher provides insight into the methodological decisions made, giving added validity to the research methodology (Ryan & Bernard, 2003). For this study, data were derived from multiple sources, with processes of gathering data informally aiding analysis through emerging feelings and ideas (Merriam, 1998). Data analysis linking data to the research questions was undertaken in three important ways: data reduction, data display, and trustworthiness (Miles & Huberman, 1994). These three data analysis components, are discussed in the following sections.

3.8.1 Data Reduction

> Data reduction is not something separate from analysis. It is part of analysis. The researcher's decisions—which data chunks to code and which to pull out, which evolving story to tell—are all analytic choices. Data reduction is a form of analysis that sharpens, sorts, focuses, discards, and organizes data in such a way that “final” conclusions can be drawn and verified. (Miles & Huberman, 1994, p. 11)

In this study, data analysis began with the transcription of verbal data (by the researcher) from the teacher and student focus group interviews followed by the generation of initial descriptive codes. A code is a word or label given to a piece of information to support data analysis. Coding was undertaken in a traditional way: by reading and re-reading printed transcripts, colour coding similar, different, and repetitive words or phrases from the respondents, recording notes in the margin, and assigning labels to chunks of data (Ryan & Bernard, 2003). From here the data was reduced by grouping “like” codes (colours) together. Coding was also both inductive—using codes that emerged from the data, and deductive—using codes connected to the study’s conceptual framework and questions (Saldaña, 2013). These codes allowed the interview data to be sorted and led to the emergence of themes (pattern codes) within and across the interview data sets, supporting connections within the data to be made (Miles & Huberman, 1994). According to Braun and Clarke (2006), a theme “[c]aptures something important about the data in relation to the research question and represents some level of patterned… meaning within the data set” (p. 82) by connecting ideas conceptually and in various ways (Ryan & Bernard, 2003).

The use of the Mathematical Learning Opportunities Observation Framework (see Research Schedule section, Stage Three (Part 1)—Classroom Mathematics Observations) enabled data to be sorted and, to some degree, allowed data reduction to occur at the time of collection. This data was complemented with the researcher diary record of thoughts and feelings throughout each observation. These comments meant classroom observations could be coded in a similar way to the verbal data, allowing emerging patterns and themes to be identified.

3.8.2 Data Display

As data gathered from various sources can be large, data displays play an important role in data organisation and assembly, helping compress and converge the data throughout the analysis process (Miles & Huberman, 1994). For this study, matrices were created so gathered evidence could be placed within categories. This was an iterative process used to summarise the collected data. For example, the teachers’ interview responses were initially colour coded, grouped accordingly, and then the codes were renamed providing a broader overview of the emergent themes. Codes and associated responses were then recorded into a matrix allowing frequently recurring ideas and patterns to be observed. An additional column in the matrix was created to capture relationships between codes. The same process was used for student focus group discussions and classroom observational evidence. Eventually, this data was recorded into one overall matrix that encompassed themes and evidence from across the different data sets (see Appendix C). These descriptive codes, derived from open coding, were then interpreted and given analytic meanings (Cohen et al., 2011).

Drawing and verifying conclusions occurred concurrently throughout the data analysis process, with matrices being an important tool in observing patterns, making meaning, and forming conclusions. These visual displays allowed data within and across data sets to be accessible and validated across multiple respondents.

3.8.3 Trustworthiness

Trustworthiness refers to the way researchers convince their readers and themselves their research findings are relevant (Lincoln & Guba, 1985) and express reality (Merriam, 1998). Lincoln and Guba (1985) suggest four trustworthiness criteria: credibility, transferability, dependability, and confirmability. For this study, credibility was achieved through the triangulation of data from multiple sources. Additionally, teacher interviews were transcribed and returned to teachers to ensure accurate and factual records of their responses had been documented. Transferability relates to the generalisability of the research and the degree to which it can be replicated to other situations (Lincoln & Guba, 1985; Merriam, 1998). Through in-depth descriptions, readers can decide the extent to which their situation relates to that described in the research (Merriam, 1998). Dependability refers to the extent to which the research processes are planned and described whereas confirmability connects the role of the researcher and their underlying beliefs (Lincoln & Guba, 1985). In this study, I have described data collection methods, processes involved in the analysis of data, aspects of ethics, and my underlying philosophical assumptions, in the hope that these detailed explanations provide trustworthiness in relation to the research findings (Merriam, 1998).

3.9 Ethical Considerations

To ensure ethical practices were observed, I attended to four layered components for examining ethical issues, as advocated by Cohen et al. (2011). Firstly, the external layer reflects codes of practice and availability of resources; the consequential layer encompasses the benefits for both the participants and researcher; the deontological layer focuses on the researcher’s duty to minimise harm; and at the core is the participant who must be shown respect and autonomy. Each layer is interrelated and works concurrently.

Aligning with the external layer and, in accordance with the Massey University Code of Ethical Conduct (2015), relevant ethical considerations for this study included informed consent, minimisation of potential harm to participants, confidentiality, anonymity, and storage of data. Special attention was given to the ethics involved in conducting research within a school context with young participants. An initial letter outlining the scope of the research and seeking consent to enter the school setting was sent to the Board of Trustees and the principal (see Appendix D) with an information sheet (see Appendix E) and consent form (see Appendix F). Next, informed consent from participants was sought and strategies were employed to minimise risk.

3.9.1 Informed Consent

Yin (2009) suggests that informed consent is outlining to participants “the nature of your case study and formally soliciting volunteerism in participating in the study” (p. 73). For this research, information sheets and consent forms were provided to teacher participants and students. As the students were under 15 years, consent was sought from both the student participants and their parents or caregivers. Information sheets and consent forms were constructed using age-appropriate language to ensure participants’ understanding of their role (see Appendices G, H, I, J, and K). Participant students (and their parents or caregivers) also gave consent to being observed during mathematics lessons (see Appendix L) and to partaking in confidential focus group interviews (see Appendix M).

3.9.2 Minimising Harm

The teacher and student participants were invited to participate in this study. All participants had the option of withdrawing from the research within the first three weeks of the study. Potential harm to participants was minimised through arranging to conduct observations and interviews during students’ regular mathematics time, at a time that best suited the teachers and programme. Those students without consent were neither observed nor interviewed for the study.

Potential risks identified and addressed were first, the researcher as a colleague of the participant teachers and, second, the researcher as the former MST to some student participants. Risk one was minimised through two-way communication to ensure clear understanding of the research purpose and timelines involved in the research process. No evaluations of teaching and learning programmes were made, apart from those grounded in the context of the study. Risk two was minimised through variety in focus group structure and through open discussions with the student participants outlining the nature of the research. Due to other students, teachers, and parents being aware that research within the school was being undertaken, anonymity could not be ensured; however, all possible steps, including assigning of school, teacher, and student pseudonyms to ensure confidentiality, were carried out. Student participants consented to respecting the privacy of other focus group members by not talking about the information shared.

3.10 Summary

The methodology chosen for this research was a single case, exploratory case study design. Teacher interviews, classroom observations, and student focus group interviews generated multiple data sources through which to explore the learning opportunities afforded to students in an ILE mathematics lesson. To aid data analysis, matrices were created to support the recording, categorisations, and triangulation of data sources. An observational framework was created to support the recording of observed occurrences during mathematics lessons. Ethical considerations underpinning the study have been outlined. The findings of the research are discussed in the following chapters.

Chapter 4: Research Findings

4.1 Introduction

The aim of this research was to explore the opportunities afforded to Year 7 and Year 8 students when learning mathematics in a newly established ILE. This chapter outlines findings from the research, drawn from participant experiences through analysis of teacher interviews, classroom observations, and student focus group interviews. These findings relate to the overarching question: what can be learned about the mathematical learning opportunities afforded to Year 7 and Year 8 students in an ILE?

In order to provide insight into classroom organisation and arrangement for learning mathematics this chapter will begin with the presentation of a typical mathematics lesson within the ILE. It will continue by outlining the key findings from teacher interviews, classroom observations, and student focus group discussions. Finally, this chapter will present four salient themes that emerged from the data analysis.

4.2 Setting the Scene: ILE Mathematics Lesson Format

The bell sounded. Thirty-one students, spread throughout two large spaces of the ILE, began their mathematics, completing self-selected basic facts activities. One teacher ensured quiet. Time ticked on the two large television screens visible across the learning space for students to self-record completion times. Simultaneously, in a breakout space, seven students and one teacher were involved in a workshop termed the "head start" group. Here, access to concepts of the upcoming day's mathematics lesson were introduced to students wanting or requiring support. Some students were asked to join this group but others had independently made the choice. After approximately 20 minutes, this group merged with the rest of the class, to a central location within the ILE. Led by one teacher, reflections on previous mathematics concepts and student questions were addressed. The lesson content was either the introduction of a new concept or one requiring further investigation carried over from a previous lesson. Charts on the windows served as reminders of previous activities (ratios, fractions, division) and coloured sticky notes contained student questions and explanations. These whole-class discussions were teacher directed but informed by student exit tickets—student-written small cards on which feelings, frustrations, and learnings from the sessions are recorded.

Then workshops began. These were teacher-led and, as the year progressed, more often student-led activities. Students opted into workshops of their choice, based on what they needed to learn. Workshop concepts were written on the whiteboard, with student names recorded below. Various sized groups were dotted throughout the ILE space. Students were seated at large "pepsi" (blue, white, red) tables, at high tables on stools, on ottomans, and in breakout spaces. One student used a whiteboard work station with his group while others used mini whiteboards, maths modelling books, and sheets of paper on which to record. Both teachers also took workshops. Upon completion of her workshop, one teacher roved, asking questions to clarify understandings at the various student-led workshops.

Next, students were given choices (generally three) over their task selection. The tasks were open-ended problem-solving tasks related to the day's mathematical concept. Students chose where and who to work with, usually in groups of three or four. Time was given to have a go. One teacher roamed the space, noting student traffic lights (red, orange, and green; see Figure 4.1), which indicated how each student was feeling in relation to the task. Those displaying red traffic lights asked questions (within and across groups) of those displaying green traffic lights and vice versa. On the floor, the other (second) teacher ran a workshop. Students chose to join in. Sometimes, students moved off to complete Virtual Learning Network (VLN) mathematics activities where they connected via Chromebook, with other students and a "virtual" teacher from across New Zealand. In these instances, glass doors were closed between spaces, allowing transparency and quiet.

Figure 4.1. Traffic lights

Towards the end of the lesson, students completed their exit tickets. The tickets were placed into baskets of red (I need help), orange (I kind of get it), and green (this makes sense to me; see Figure 4.2). These were read and used by the teachers to inform the next day's head start group and the content of future workshops. Mathematics sessions ran four days a week for approximately one and a half hours per session.

Figure 4.2. Student voice was shared via exit tickets

4.3 Teacher Interview Findings

Both teachers within the ILE were interviewed pre and post student data collection. The nature of these interviews was to gain first-hand understandings of the teachers' goals underpinning mathematics lesson implementation, including the way the ILE was set up to afford mathematics learning opportunities. In analysis of the teacher interview data, three key factors influencing the set up of the ILE emerged. First, the fluidity and flexible use of space for mathematics lessons provided opportunities for variety in grouping structures and multiple workshops. Second, by affording opportunities to direct their next learning steps, students were positioned as central drivers in their mathematics learning. Third was the way the teachers emphasised the collective group of students rather than two individual cohorts.

4.3.1 Fluid and Flexible use of Space

Influencing set up of the ILE for mathematics learning were aspects of fluidity, openness, and calm. Purposeful in efforts to create a space devoid of clutter, the teachers described how furniture was pushed back towards the walls, creating a free-flowing space through the centre and allowing smaller areas to be used at different times and in different ways. The teachers noted that the ILE set up was an evolving process influenced by utility of different spaces and mobility of furniture: "we wanted a space that was going to flow nicely without being cluttered… all our furniture is basically pushed back against the walls so we can have a free-flowing, big space, where people don't feel crammed" (Hine, I#1).

To make the most of the space, various zones within the ILE were created. These included two large central areas used for groups or whole class activities and smaller breakout spaces where workshops, small groups, and individual learning occurred. One breakout space was maths focused and another doubled as a teacher office and calm zone— a relaxed space, with a bean bag, posters, and tools for students requiring time out. Another zone, tucked away at one end, was designated device free; yet another contained kitchen facilities and an art area (see Figure 4.3).

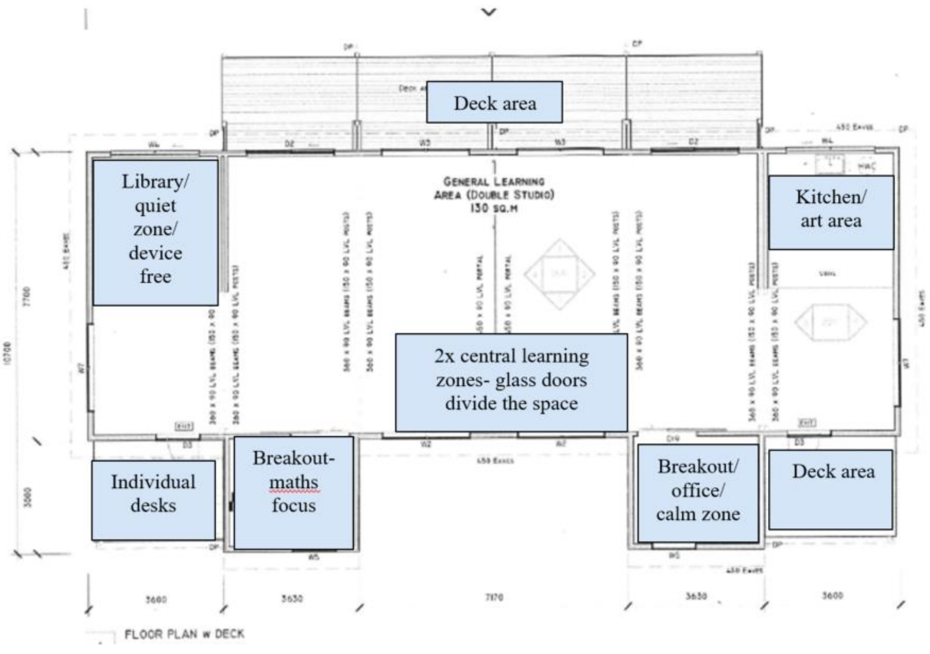

Figure 4.3. ILE classroom layout

Flexibility of space and furniture mobility were key features within this ILE. As Teacher Anna noted:

> It's flexible, no one has a fixed spot where they work. We find the students move to different spaces depending on who they are working with or what they are doing. Students don't have to sit with the same people, they move furniture round to suit, there are places for them to go, they've got options.

The use of space and student-initiated changes in furniture design within the ILE allowed flexibility in grouping structures, which supported multiplicity in social interactions and interrelations.

4.3.2 Students at the Centre

The positioning of students as central to the learning process aligned with teacher philosophies regarding the teaching and learning drivers. To meet their aspirations to "create an environment where students have an opportunity to own their own learning and have agency for what and how they are learning" (Hine, I#2), the teachers used student voice to inform their planning in mathematics. Hine commented:

> We are really reliant on student voice. This term our whole planning has changed dramatically; instead of knowing where we are heading overall, our planning changes day to day based on student feedback and what they need workshops on. So, from student exit tickets, we are basically planning for the next day.

Another deliberate strategy aligned with the ILE organisation was the frequent use of choice over where learning occurred, group formation, and task selection. Students' choices helped steer their learning direction, and these choices were supported and scaffolded by others within the ILE.

> They [the students] support … each other and I think it means a lot more … when they see others wanting to learn they feed off that and when they are in

> those smaller groups they are so enthusiastic about proving something they actually want to step up (Hine, I#2).

However, although students had ownership over what they learnt, who they learnt with, and where the learning took place, this was bounded by the underlying structures and routines within the ILE.

4.3.3 Students as a Collective Group

Teachers in the ILE viewed the students as a collective group. Versatility in grouping structures meant students moved within and between spaces based on choice or grouping, independent of whose 'class' they were in. Teacher Anna's statement confirmed this: "They are all ours. We consider them all as one, we both monitor them all." That is, every student was considered part of the whole—equally as important as each other—to both teachers. At no stage throughout the research were groups identified based on their predetermined class.

Overall, teacher interviews suggested that ILE set up for learning mathematics was influenced by utility of space and through positioning students as central to the learning process, affording them choice and voice in directing their learning. This was realised through teachers' viewing of the class as a collective community where each student's learning was equally important to both teachers.

4.4 Mathematics Lesson Observation Findings

Observations of 15 mathematics sessions occurred throughout the research. These observations were multi-faceted in that mathematics lessons generally went for one and a half hours and were comprised of multiple interactions and learning experiences. From these observations, three key factors linked to opportunities to learn emerged from the data. First, there were the various means afforded for student communication in mathematics sessions. Second, there was the role of classroom norms and expectations that underpinned mathematics learning within the ILE, and, third, there was the role of digital technology in mathematics sessions.

4.4.1 Mathematical Communication

Social and socio-mathematics norms around mathematical discourse were evident in the ILE. Students were expected to inquire and justify their mathematical contributions through multiple forms of verbal, non-verbal, and written means. Verbal communications involved group and whole class spoken interactions. Non-verbal communications involved students' use of thumbs—agree, disagree, or undecided—as a way of sharing their understanding in the moment. Individual student, non-verbal communications also took the form of traffic lights—red, orange and green, key-ring bound, pieces of laminated card (see Figure 4.1)—informing student understanding of the task they were undertaking. Furthermore, written student communications, termed exit tickets, were recorded on post-it notes and communicated mathematical reflections, feelings, and future directions. These communications (placed in a red, orange, or green basket) informed teachers of students' needs and were used to determine the content of subsequent workshops. The following example from O#5 field notes captures the communication—and, in particular, the input of student voice—within the ILE:

> There is a sense of community and empowerment achieved through constant communications between teachers and students. Teachers listen and are responsive to the views of students. Students are heard. They are presented with opportunities to direct their learning and through exit tickets, outline their next steps to make mathematical meaning. Student voice is evident, valued and influential in informing mathematical decisions and directions. By having a voice, students are actively shaping their environment and their learning.

This observational reflection presents students as central to their learning of mathematics, capturing the methods of communication established within the ILE. Collectively, these varied communications convey student ownership over their mathematical thinking.

4.4.2 Classroom Norms in Mathematics

Underlying social norms were evident and well established within the ILE. Visual poster representations of the norms depicted all class members paddling a fleet of "waka" towards a collective destination: "to achieve our best we all do our part" and "paddle together, work as a team, help each other". The focus on collective understanding, effort, and working together was valued and enacted in the mathematics classroom. For example, the social norms of collective support and effort were emphasised during an observation where a group was working on an algebraic activity. After being given time and opportunities to ask questions, students took turns explaining and justifying their processes. When one student unexpectedly called out an answer, the group made their displeasure clear: “That’s stopped our learning!” and “Why did you have to tell us?”

These student comments highlighted classroom expectations that it was not considered acceptable to share answers without explanations as it stopped the thinking of individual group members. This reinforced the notion that the answers themselves were not valued without the processes underlying their generation. The students were genuinely dismayed at the disruption to their thinking.

Similarly, an observational note captured aspects of participation and ways of working as they evolved within the ILE:

> Students are more independently using mathematical dispositions. For example, they are showing greater perseverance when undertaking tasks and are accepting mistakes as opportunities to learn. Some students have adapted to changes more quickly than others. However, as classroom norms are reinforced through teacher (and some students) words and actions, they are beginning to be embraced, in varying degrees, by all.

4.4.3 Digital Technology

Students had access to Chromebooks. Chromebooks are cloud-based, laptop devices that use Google Chrome as the operating system and store data online. Observations indicated Chromebooks were used periodically to source, view, and share information, and extend thinking. For example, in one lesson, groups of students used online collaborative documents to record questions, understandings, and wonderings about analogue clocks. The Chromebooks connected to the central television screens, which displayed the recorded group’s questions. Following this, groups watched a video—new age Kiwi kids struggle to tell the time with old-age clocks—and used collaborative Word documents to record new ideas and questions arising from the video. The following field note observation captured this activity:

> The use of one Chromebook per three students, emphasised the importance of group collaboration and created a middle space from which to work. The Chromebook was central and visible, acting as an invitation to join in, where students' ideas were recorded. Some groups had a designated recorder while others adjusted the Chromebook for self-recording. The questions recorded by groups, were displayed on the central classroom television screens, allowing ease of access for whole-class discussions. Digital technology was used as a tool for exploring mathematical concepts, allowing connections to be made within and beyond the classroom environment.

During observations, digital technology was not used for games or as a reward for fast finishers. Instead, its use promoted inquiry and further investigation and interaction beyond the school. Making videos and documents re-accessible within "Hapara Workspace" allowed access beyond the class environment. Hapara Workspace is a digital space where classroom resources, tasks, and activities can be accessed. Therefore, students could self-reflect and revisit their learning outside of school time.

4.5 Student Focus Group Findings

Following researcher observations students discussed their opportunities to learn mathematics within the ILE, via focus group discussions. Four key findings emerged from the data. First, students outlined variations in grouping structures and how they supported the development of their mathematical understandings. Second, student participants reported the role of challenge, persistence, and learning as processes that involved being in the learning pit. Third, students discussed opportunities to lead workshops as well as opportunities afforded through access to two teachers. Finally, students made comparisons between mathematics learning in the ILE and previous single-space environments.

4.5.1 Grouping Structures

Within the ILE, variations in grouping structures used for the range of learning activities were evident. These structures included whole class, individual, pair, and small group variations.

Most days, while the majority of the class completed basic facts activities, a small group of students engaged in a workshop with one teacher in a breakout space. Termed the head start group, the intent was to provide students with insight into the upcoming mathematics session, presenting opportunities to explore and apply concepts that would be repeated with the class. These were fluid groups where students could opt in, self-selecting additional support. Sometimes, however, teachers would personally ask those students whom they felt would benefit from the small group intervention. In focus groups, students reported positively on the opportunities to engage in the head start group as follows:

> *Kegan:* "It helps us by giving a sneak peek of what we are going to be doing in the class, so we get to do it a bit earlier."
>
> *George:* "After the workshop we do our normal work that the whole class does; we just use what we were doing in the workshop with the whole class."
>
> *Karl:* "The head start group helps me because I learn more about an idea so I don't get stuck as much in maths time. It helps me to do it again with different people in the class. It makes me feel more confident."

Observations of these students in the whole class format noted that these students were active, engaged participants and willing contributors.

4.5.2 Mathematical Challenge and Perseverance

Students within the ILE appeared to enjoy mathematical challenge. Observations noted that students were keen to engage in and persevere with activities that were open-ended and required longer time frames for completion.

The ownership to develop an individual or group solution where appropriate was evident, with students resisting being told an answer, especially by a peer. Instead, they liked to check in with others, compare their thinking, and change their thinking but not be told how to do the thinking. For example, in the following observed episode, Alex and Joe persevered to consolidate their understanding of ratios. After having put their answers and explanations to a problem on a poster alongside their peers, Joe commented:

> We realised we had very different answers from everyone else. We were told if we disagreed with other students' answers, we had to find out why. So, we went to other groups and asked questions to try and make it make sense.

Alex and Joe then proceeded to give a detailed explanation of how they solved the ratio problem, including their initial mistakes: "We thought to get the answers we would just halve the number, that's what we thought ratios were…"

In this example, Alex and Joe showed perseverance and self-responsibility for making mathematical meaning. Although their initial ideas proved incorrect, given the time and opportunity, both boys used access to peer knowledge to gain understanding. There was no emphasis on completion of another task; instead, teachers encouraged both boys' continued exploration and use of peer knowledge. Upon reflection, the boys articulated their perseverance: "We knew we were getting closer to understanding. The task was exciting and fun and made you want to carry on to find the answers."

Researcher observations also noted how students typically made task choices that would challenge their thinking. For example, given a choice of three tasks based around pocket money ratios, Mia stated: "I'm choosing the best fit for me. I want it to be challenging but not too challenging—that's frustrating!" Another student, displaying a red traffic light, wanted to continue with the challenge at hand: "What if you are on red and you're in the pit and finding it challenging but know you are getting somewhere? Do you have to come to a workshop or can you keep on persevering?"

Similarly, in a focus group interview, Ruby and Vicki's reflections on the time it took to complete a challenging algebraic activity, which had been a focus for three sessions, capture the inherent sense of self-satisfaction. Although challenging, the nature of these tasks meant students had to persevere and integrate their thinking with that of their peers:

> *Vicki:* "I think because it took a long time it actually built our knowledge and made it stronger and I feel happy because I persevered to complete it."
>
> *Ruby:* "Yeah, it's like you can see the edge of the learning pit and you are just about to climb over it. It makes you feel satisfied."

In her post interview, Teacher Anna acknowledged accepting challenge was an important part of learning in their ILE:

> We spend a lot of time talking and understanding what it's like when you are working through the learning process—so they [the students] know they will have moments of frustration when they are in the pit and they can talk about how to get themselves out of it. We talk about perseverance and encouraging one another.

Mathematical challenge via open-ended tasks, was afforded in the ILE. Importantly, in conjunction with challenging tasks, time was allowed for students to sense-make, revise thinking, and articulate new ideas. The action of active learning, responding to challenge and persisting with struggle were enabled within this ILE.

4.5.3 Student-led Workshops

In Term 2 of the year, students were supported to lead mathematics workshops. The workshops were recorded on the central whiteboard. Students chose one that met their needs, writing their name underneath. Opportunities for students to teach each other were perceived by students as helping others and also consolidating their own understandings. As Tane commented, "Explaining it out loud to others helps me learn." Similarly, Teacher Anna mentioned:

> When they [the student workshop leader] explain it to someone else, it is really helping to secure that understanding and knowledge as they are trying to explain it and verbalise it. It's a win, win—for the ones that are learning and also for the ones who have just recently learnt it. They feel empowered and love to be teaching someone else (I# 2).

Likewise, Max explained how a student-led workshop helped him make sense of dividing large numbers:

> In the workshop, [a student] showed me their strategy. He explained it as a story, and it made sense. When a student explains an idea, it kind of makes more sense from their perspective because that's how they've learnt it. They have a different way of explaining it from a teacher. When the teachers explain it from their perspective, they explain it more mathematically. I think students should be the ones to lead the workshops, unless none of us know.

In these examples of student-led learning, students were afforded agency through choice of their next steps by deciding which workshop they should opt into. Comparatively, the students leading the learning were afforded opportunity to consolidate their understandings by sharing their thinking and through answering the questions of their peers. As outlined by Max, students valued the perspectives of their classmates, articulating that hearing it from their peers supported greater understanding of new mathematics concepts.

Another outcome of student-led learning was building classroom experts and capability. Classroom observations noted that students requiring support were beginning to take opportunities to independently access other students to support their understanding. In the following field note excerpt, Mia is approached by two students seeking to clarify her division strategy in solving 837÷9:

> Mia explained she started by asking herself the question—what's going to get me close to 837? Then she outlined her recollection of 9 x 9 = 81, and how she used this knowledge to solve 90 x 9 = 810, saying, "Now I'm multiplying it by

> ten. Making it a tidy number makes it easier and the answer is pretty close to 837. I knew I needed 27 more (because 810 + 27 = 837) and 3 x 9 = 27." Next, Mia explained adding 90 + 3 would inform how many times 837 could be divided into groups of nine.

The two students who had independently approached Mia were keen to understand her strategy. They asked questions and encouraged Mia to repeat her ideas. The teachers took no part in the discussion—it was completely student driven. Could it be that the student-led workshops were opening a space for increased student-to-student-initiated meaning-making in mathematics? This could support and promote a shift in focus from teacher-centred to more student-centred learning.

4.6 Learning Mathematics in an ILE

Throughout focus group discussions, students shared their views on learning mathematics within their ILE, making comparisons to previous single-space experiences. Of the 25 students interviewed, all but one expressed their preference for the ILE. The aforementioned student could not decide as he saw differences between the two environments but did not consider either preferable. Salient responses from other participant students focused on the accessibility to two teachers, an aspect they considered very positive in supporting their mathematics learning. Students also reported access to teachers' varying perspectives, opportunities for varied workshops, and not having to wait for teachers as benefits. Take for example this focus group discussion involving Mia, Madison, Leilani, and Vicki:

Mia: "Two teachers can challenge you to solve problems in different ways."

Vicki: "Yeah one teacher teaches you one thing and the other teaches you another thing in a different way."

Leilani: "So, you can learn different strategies."

Mia: "It gives you two chances to try it…"

Madison: "…and if one [teacher] is working with a group, the other one is free to talk to you. You don't have to wait to ask questions."

Similarly, Grace and Jake summed up their views on having two teachers:

> *Jake:* "Two teachers gives you options. If you are not sure of something, you could ask one teacher and then the other teacher to get both teachers' perspectives and gain a better understanding of it."
>
> *Grace:* "I like having two teachers because it's more likely a teacher will come to you. With two teachers there's more to go around, I guess!"

Specific opportunities afforded in an ILE, compared to the single-space equivalent were also noted. These included the ability to find spaces that suited learning needs, especially quiet zones within the larger space. As Ruby noted, the ILE provided opportunities for quiet learning spaces:

> I definitely prefer this year's space as it's got lots of spaces for different learning. Last year, if you wanted to do maths learning in quiet you couldn't get a space; the whole class had to be quiet. Here, you can shut the doors in the middle and do different activities at once.

Students emphasised the comfort of the ILE and opportunities to spread out and interact with various students, not just the ones they sat next to as in previous classes.

> *Amelia:* "It's bigger, you can learn differently. If one group wants to learn maths in here and another wants a workshop, you can close the sliding doors, it's easier and everyone can hear."

Mentioned by many students was that the affordance of space allowed students to select to move based on personal preference or what suited their learning needs in the moment:

> *Jake:* "You're able to spread out without being confined to a small area with everyone else. In maths, if there is noise at one end, you can move to the other end or close the doors—you've got choices."

Eva: “I prefer the ILE because there is more space and different rooms to work in and especially the two teachers, that’s good, it helps us a lot.”

4.7 Summary

In researching students’ opportunities to learn mathematics in this newly established ILE, key findings emerging from teacher interviews, observations, and student focus group discussions have been presented. Teachers and students alike noted the flexible use of space supported both individual and collaborative opportunities to learn mathematics. Both teachers and students were openly supportive of the new ILE arrangement, with the two teachers (their varying perspectives) and options for interaction it afforded.

By coding responses and analysing findings, four salient, overarching themes supporting students’ mathematical learning opportunities emerged. These themes—relating to opportunities afforded through flexible, spatial arrangements, student agency, students leading the mathematics learning, and learning within a classroom community—will be examined in relation to current literature and the study’s research questions in Chapter 5.

Chapter 5: Discussion

The purpose of this chapter is to discuss, explore, and examine the key research findings, making connections to research literature and the questions that underpin this study. It seeks to progress understanding in how mathematical opportunities can be afforded within an ILE through four salient themes that emerged from the data: affordances of spatial arrangement, student agency, students leading the learning, and a mathematics community of learners (see Figure 5.1). To do this, discussion of each theme will highlight areas that converge, diverge, and extend current understandings. It is important to understand that these themes merge, overlap, and do not stand alone. Framed within the wider classroom context, the themes are intertwined within the individual, social, and spatial arrangements of the ILE.

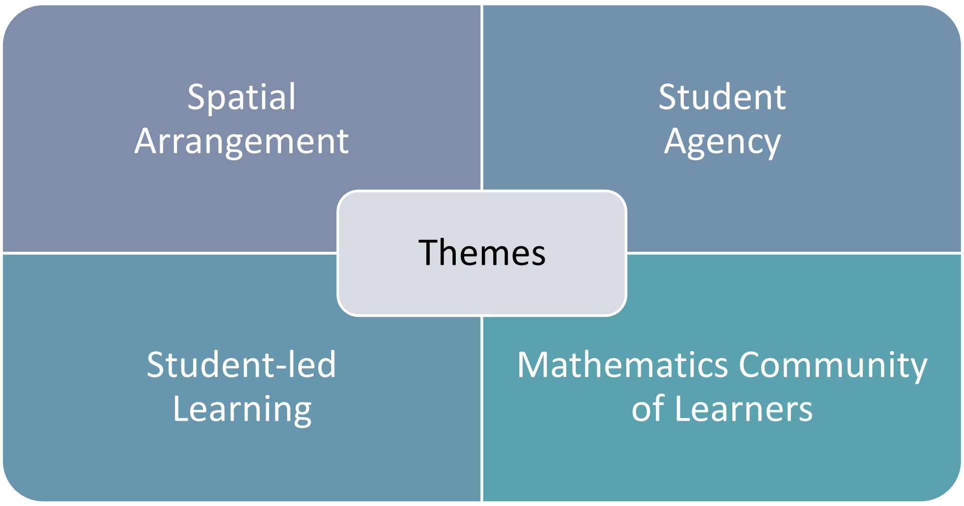

Figure 5.1. Themes emerging from the data

5.1 Theme One: Spatial Arrangement

Massey (2005) proposes representations of space utility as occurring in various ways. First, the use of space is an outcome of social interrelations; second, it presents a common place for various learning trajectories to co-exist; and third, space is constantly changing through reconstruction by those within. This study found spatial arrangement merged aspects of space utility and mobility of furniture, affording easy movement to create zones, sub-zones, and student-created spaces. Spatial arrangements included both organisation of tangible elements—furniture, such as ottomans, bean bags, benches, and high stools—and non-tangible aspects—access to resources and flexibility (Dane, 2016). The ILE presented as having a clear-of-clutter arrangement, its pathways providing access to mathematics resources and supporting multiplicity in student actions and interactions. The open spaces created active surfaces (Dane, 2016) where floor and wall spaces were used to record, share, and reflect upon learning.

Spaciousness—termed by Dane (2016) as a "valuable educational commodity" (p. 216)—was viewed by research participants as providing new possibilities and a sense of freedom. While, Byers, Imms, and Hartnell-Young's (2014) study concluded that open space and arrangement had a measurable positive impact on student engagement, Dane (2016) noted that spaciousness is subjective, suggesting there is a point at which a space begins to or stops feeling spacious, relating to numbers of people and objects within. Therefore, classrooms must be sufficiently large to cater to different learning activities (Wall, 2016) and student numbers. Across the discussions, participants in this study emphatically emphasised 'space' as an affordance, collectively voicing their opportunities for mathematics learning. These opportunities will be discussed through concepts of spatial zones, grouping structures, access to two teachers, and multiple focal points.

5.1.1 Spatial Zones

Findings showed that zones and sub-zones within the ILE afforded new, purposeful, and interesting spatial opportunities for learning mathematics. Spatial zones within the ILE evolved in various ways. First, the physical building determined the layout (for example, breakout spaces). Other spaces were influenced by teachers' observations of student learning within the ILE. For example, a device-free area was created, ensuring devices were centrally located for ease of monitoring. Further zones were reconfigured through teacher and student collaboration. For example, a strictly enforced quiet zone evolved from student-initiated requests. Breakout spaces were flexibly used "places-within-places" (Massey, 2005, p. 179); the teacher office was a group learning space and a student calm zone.

Observations showed students constructing and reimagining spaces through physical rearrangement of themselves, resources, and furniture, affording both individual and collective options. These sub-zones within the larger area were self-created “maker spaces” (Imms et al., 2017, p. 11) designed in the moment to meet students’ individual or group needs. For example, one student spontaneously placed bean bags in front of a bench. He sat on the bean bag, stretched his feet under the bench, placed his mathematics activity on the bench top and settled comfortably into his independent, self-created space. Thus, spatial relations occur through interactions between people and objects within a specific space (Charteris et al., 2018).

Whereas in past years all participant students had learnt mathematics in one central location, within the ILE, these boundaries were expanded. Opening up previous boundaries to Madison meant: “Different activities can be going on in different spaces with different teachers. There’s lots more possibilities.” The varying zones were moulded to meet learning requirements: open areas, smaller breakout spaces for group learning, and quiet zones for independent learning. Students were afforded choice over where they did their learning, although the evolving nature of the ILE saw a newly trialled colour system introduced, which meant students stayed within the larger zones until they earned the privilege of choosing learning places out of the teachers’ view.

5.1.2 Grouping Structures

The spatial arrangement in the ILE afforded multiplicity of use, allowing changes in functionality and diversity that accommodated various grouping structures. Spatial openness and use of glass partitions removed visual barriers, allowing observable settings where groups interacted. Space was not considered static; instead, it evolved and changed, flexing to find a best fit for the learners (Bray & McClaskey, 2013).

Study findings indicated that fundamental to mathematics learning within the ILE were grouping structures that afforded opportunities for acceleration via the head start group. Acceleration strategies included timely access to new mathematical concepts, presented firstly with a teacher in a small group and, secondly, directly following, within a whole class context. Acceleration strategies are associated with increases in student self-efficacy and skill application, and build on connections to prior learning (Rollins, 2014). This is important as students' mathematical identities, willingness to participate, and perceptions of themselves as learners are influenced by meaning-making and success. Describing her head start students within the class context, Teacher Anna remarked:

> We've noticed a massive difference [in these head start students]. It's exciting to see students that in the past may have been silent, uninvolved, disruptive or really quite lost are the ones putting their hands up, joining in and really being quite an active part of group discussions. They feel like they have something to contribute, they're feeling empowered.

Observations confirmed variations in grouping structures promoted access to and use of resources, both tangible and intangible. The affordance of space presented opportunities to configure grouping structures for various mathematics activities—elements deemed essential for effective learning to take place (Dane, 2016; OECD, 2012).

5.1.3 Teacher Resourcing

Research participants emphasised how two teachers presented positive opportunities for mathematics learning, opportunities they claimed were unavailable in single-space classrooms. Most notably, space configuration allowed multiple workshops to take place without interruption. As Teacher Hine noted:

> Two teachers can split off and accommodate groups a lot easier whereas in a single cell, group work is hard; you are constantly looking up. It's sort of like multi-tasking, and it's proven you can't multi-task because you do half a job whereas in here [ILE] you can do a full job!

However, students were also cognisant of the advantages of two teachers. As Claire described it: two teachers supporting mathematics learning meant "even if one teacher is taking a workshop, you can always ask the other." Multiple teachers allowed effective use of breakout spaces for workshops or Virtual Learning Network (VLN) extension programmes to be supported. By arranging space and teacher resourcing in this way, students were afforded opportunities through flexible teacher arrangements and resourcing that underpinned the mathematics programme. The teachers were clear about best utilising teacher resourcing and time: “Having two teachers means you can go more in-depth in workshops while someone else is roving. You can keep closer tabs. I think we can respond to student needs more readily when there are two of you” (Anna, I#1). These findings align with recent research that asserts student access to multiple teachers affords increased opportunities for learning and a greater emphasis on individual student needs (Hurd & Weilbacher, 2017).

5.1.4 Multiple Focal Points

In this case study, the spatial arrangement within the ILE effectively disrupted opportunities for students to become passive recipients of mathematics through multiplicity in classroom focal points. Termed by Byers et al. (2014) as a “polycentric layout,” (p. 4) multiple learning zones within the space de-emphasised there being a front of the room. For example, two wall-mounted televisions, multiple whiteboards, clusters of seating, and movable teaching stations were spread throughout the ILE, affording options from where mathematics learning could occur. While the central, whole class area was primarily used as a forum for student discussion, strategy explanation, justification, and debate, the multiple focal points reinforced the ILE space as flexible and malleable—a living ecology moulded by the students and teachers within.

In summary, spaces in the ILE afforded possibility. They were flexible, had multiple uses, and presented opportunities for reconfiguration. The theme spatial arrangement is important in outlining space as an affordance—in learning mathematics within the ILE. Although teachers were initially influential in creating physical spatial arrangements through furniture positioning, over time, student interactions moulded the space, supporting individual learning and social interactions. This reinforces spatial arrangements as relational where student interactions with class mates and objects are created collectively, within physical and social spaces (Mulcahy, Cleveland, & Aberton, 2015).

Across the discussions, participants repeatedly emphasised their preference of the ILE over single-space classrooms, citing the openness and variety of choices it presented. Importantly, the open nature of the ILE, its varying focal points, mobile furniture, and active spaces presented an agile environment, influential in creating calmness, where students knew what was expected.

Moreover, the evolving spatial arrangements encouraged students to initiate, modify, and reflect upon mathematical activities, providing a foundation from which agentic mathematics opportunities were afforded. Although spatial opportunities were bounded by classroom routines and spatial functionality (Deed & Lesko, 2015), students were influential in seeking out spaces that suited their learning.

In capitalising the benefits of space, this study demonstrates the importance of understanding that spatial arrangement of ILEs is more than physical classroom space; they are flexible, living spaces that must evolve "to support the adaptable delivery of teaching and learning programmes to meet the learning needs of all students" (Wall, 2016, p. 24). However, given the relatively small size (physically and number of participants) of this ILE, further research is required into desirable student numbers where spatial arrangements for mathematics learning remain an affordance.

5.2 Theme Two: Student Agency

A focus of this study was to understand how students described their opportunities to learn mathematics within their ILE. Emerging from student focus group conversations was the theme student agency. Students emphasised their opportunities for mathematical choice through task selection, deciding where and with whom to work, and through opportunities to reflect and evaluate their ideas through comparisons to the thinking of others. Students collectively and repeatedly highlighted their opportunities to "have our say" (Joe) and provide "our own input and ideas" (Amelia), promoting ownership and personal direction to their learning.

Student agency takes centre stage in advocated mathematics reforms. As Garrity (2015) states:

> There is a significant and growing demand for learners to be able to do more than receive instruction, follow a learning path designed by educators and complete problems and assignments presented to them by an adult. Learners need to develop the capacity to shape and manage their learning without over-reliance on the direction and control of others (Why learner agency is needed section, para. 1).

However, it is important to note that teachers cannot just give agency to students as it is not "unidirectional" (Klein, 2002, p. 67); instead, teachers must open spaces from where opportunities for agentic behaviours are afforded. Research suggests student voice directly impacts agentic behaviours in three key ways (Wagner, 2007). First, it positions students as actively involved; second, it is effective in gauging student experiences; and, third, it presents a student's individual character, culture, and identity. In this case study, each of these three aspects was observed to underpin agentic practices supporting students' mathematics learning opportunities in the ILE. By being afforded agency through decision-making and directing their learning, students learnt ownership and self-responsibility.

Research findings showed students were presented with multiple opportunities for agency and autonomy within the ILE. First, they were afforded agency through choices of where to learn, and interactions with and manipulation of furniture to meet their learning needs (Dane, 2016). The ILE was promoted as a context where interactions between objects and space supported spatialised practice, opening opportunities for student agency (Charteris et al., 2018) through choice and empowerment. As Teacher Hine mentioned, "We want the children to learn and practice their independence, so it's a cool opportunity for them to find space that works for them." These findings align with concepts presented by Bolstad et al. (2012), who suggest that access to, and use of, new and emerging resources (for example, spaces) challenge traditional notions of teaching and learning.

Second, students were positioned as active participants in learning mathematics by being given an authentic voice that directed their learning. This meant students shared their experiences and were encouraged to be agentic in their learning through self-responsibility and reflection that involved both a current and forward-looking focus on their next steps. Positioning students as active participants draws on research by the International Academy of Education (IAE)—which integrates research from multiple areas of psychology (for example, cognitive and social)—in advocating for students being actively involved in authentic goal setting and through exercising authority over their learning (Vosniadou, 2001). Similarly, positioning students as central to their learning is a key philosophy underpinning ILEs and aligns with Principle 1 of the 7+3 framework (OECD, 2017).

Third, students were afforded conceptual autonomy (Cowie, Otrel-Cass, & Moreland, 2013) in that they were given choice over methods used to solve tasks. They had opportunities to explore, adapt, and evaluate the thinking of others in pairs, and in group and whole class situations, promoting movement away from emphasis on right or wrong answers (Boylan, 2010). Conceptual agency is important in positioning students as active constructors of their own understandings, not passive receivers of knowledge (Boaler & Greeno, 2000).

Lastly, students were afforded collective agency. This meant while working in groups, students made choices about how to lead, listen, and respond to the ideas of others, persisting as a group during challenges. Collective agency is important because students must learn to work and contribute in various ways, developing competencies that go beyond individual learning models (Hipkins, Bolstad, Boyd, & McDowall, 2014). Furthermore, collective agency fosters key competencies—thinking, using language, symbols, and texts, relating to others, managing self, participating and contributing—behaviours considered integral for 21st century learning (MoE, 2007).

5.2.1 Student Voice and Choice

This study's findings outline that student voice and choice were important in promoting understanding of mathematical concepts through deep learning. As advocated by Imms et al. (2017), deep learning can be classified as learning for meaning-making and observed through student actions to understand, make connections to prior learning, and reflect on ideas. The findings here affirmed research by Imms et al. (2017) that noted deep learning characteristics were more widely exhibited by students in flexible learning environments and contributed to increased motivation and positive dispositions in mathematics.

Student voice seeks to gather student contributions and "create a space for students to make claims of their own" (Cook-Sather, 2014, p. 141). Rollins (2014) suggests student ownership over learning is afforded through eliciting feedback, letting students know their input is valued, and affording a sense of control over their learning direction. She suggests this promotes engagement and a sense of self-responsibility, and leads to student autonomy. In affording agency, the deliberate seeking and valuing of student voice supported teachers to plan workshops to meet students' mathematical needs. Expectations for students to take time reflecting on their learning, both orally and via exit tickets, provided opportunities for sharing next learning steps. Specifically, the exit tickets provided a structure from which students were afforded an active participatory voice and a sense of empowerment (Cook-Sather, 2014; Flynn, 2014).

A further finding showed student choice and voice presented purposeful opportunities for student participation through constant and consistent interactions that fostered independence and ownership over their mathematics learning direction (Cowie et al., 2013). This participatory norm supported changes in how diverse students interacted with and participated in mathematics (Flynn, 2014; Gresalfi, 2009). For example, the gathering of student voice orally, through traffic lights, and in written form meant quieter students were given an equal voice alongside their more vocal peers.

Moreover, the gathering of diverse student voice occasioned opportunities for students' unique perspectives to be shared. This was important as students learnt their opinions were valued, they had some ownership over mathematical content covered, and authority within the ILE was more distributed. That is, participatory opportunities reinforced learning as a shared endeavour and held students increasingly accountable for individual and collective understandings.

However, this study also highlighted that affording student agency in directing their learning could be challenging for teachers. Daily reading of exit tickets, making connections to prior mathematical concepts, and structuring progression framed within individual student needs meant constant communication for teachers and day-to-day planning for workshops. Therefore, mathematics planning direction could quickly change course based on student feedback of their needs. Just as in the single classroom, managing their workload presented challenges for teachers' planning for multiple learning areas. Moreover, as teacher decisions in the ILE were always made collaboratively, Teacher Hine expressed: "I feel like sometimes I lose a little bit of ownership in terms of planning…we have to do a lot more communication."

In summary, this study found that developing and supporting student agency proved fundamental in the underpinning of teaching and learning mathematics within the ILE. Over time, student agency was developed and enacted in multiple ways. First, students were afforded individual agency, which positioned them as self-regulated, active participants and central drivers in their learning. Second, student agency was interdependent—it did not occur in isolation but, instead, connected to the sociocultural classroom context. Third, affording agency promoted social agentic actions where students were beginning to take greater responsibility for their mathematics understandings as well as that of their peers (Osborne, 2016). Importantly, afforded agency offered insights into students' mathematical thinking, allowing learning opportunities to be tailored for different students and presenting multiple entry points from where mathematics conversations could begin.

5.3 Theme Three: Students Leading the Learning

A third theme that emerged from the data concerned the opportunities afforded to students to lead the learning in mathematics. This recent development within the ILE was positively received by student participants. Findings suggested students felt comfortable learning new concepts from their peers. Participants noted that peers were able to present the mathematics more informally and in ways they understood. As Eva pointed out: "Everyone has their own way of showing strategies, so we get to see which one works best for us."

Researcher observations of students leading the learning and sharing strategies to their peers noted several positive aspects. First, students were reinforced as active participants, armed with concepts worthy of peer consideration, fostering confidence, and sense of purpose. The social nature of the student-to-student interactions, nurtured cognitive restructuring (Webb, 2009), promoting development of individual understanding. A notable feature of interactions was the opportunities for both student leaders and learners to reflect and reorganise mathematical understandings. Students, initially "a bit nervous" (Tane), proved purposeful in sharing ideas with others. The student-led learning presented opportunities for more active partnerships between teachers and students to be developed and, consequently, each teacher became one of many sources of support available (Hunter & Anthony, 2011). Thus, the distributed classroom authority once more positioned students as the central drivers in their learning (OECD, 2012).

A second positive aspect was that explaining and justifying their concepts to peers provided opportunities for students to consolidate their own understandings. Expectations for student leaders to rehearse and clarify their thinking before sharing aloud helped to ensure that their ideas were communicated in ways others could understand (Webb, 2009). Simultaneously, students gained understanding based on evaluations of other students' ideas (Hunter & Anthony, 2011).

A third positive aspect was that students opting into student-led workshops were encouraged to identify their learning needs and the associated workshop that would best accommodate their next steps in understanding a concept. These timely, social interactions with more expert-like peers allowed student-learners to complete tasks and learn strategies within a "Zone of Proximal Development" (ZPD; Vygotsky, 1978, p. 86) or just beyond those they could complete independently.

Lastly, by both leading learning and accessing the thinking of their peers, students were most likely to be focused and engaged. Research (for example, Dumont & Istance, 2010) suggests engagement and motivation are gatekeepers to learning and have significant impacts on students' cognitive, affective, and behavioural development. This is important as levels of engagement are associated with personal investment on the part of the student, willingness to become involved in the activity, and active participation (Attard, 2012).

Student-led learning encompassed constructs of student agency and distributed authority, merging within the themes already outlined. It aligns with the 4 C's—creativity, critical thinking, collaboration, and communication—competencies deemed important for 21st century learners (P21, 2007). An additional benefit of student-led learning is the opportunity for "assigning competence" (Boaler, 2016, p. 134) to students who may be perceived to be of a lower status whereby a teacher publicly focuses the class's attention on an idea or strategy a student has presented, acknowledging it as a valued contribution (Boaler, 2016).

However, student-led learning is not without its challenges. In order to gain momentum in the ILE, students required ongoing scaffolding and prompts so they could learn to share ideas without just showing the procedure. Time and management were also factors, particularly with larger student numbers. Challenges exist in finding common ground where teachers and students prioritise what concepts are most important and use student capabilities to open space for successful mathematics learning. Aspects of power may need to be addressed as students take on a variety of roles (Nelson, 2017a).

5.4 Theme Four: A Mathematics Community of Learners

A final theme to emerge from the research was the mathematics community of learners within the ILE. Learning communities collectively construct goals, share ways of communicating and interacting, and position ideas as classroom currency (Hiebert et al., 1997). Classroom communities are important in establishing mathematical meaning-making through joint negotiation and participation in the mathematical practices afforded within the classroom (Anthony & Hunter, 2005). Therefore norms—practices that shape the nature of students' engagement with mathematics (Gresalfi, 2009)—evolved and were refined throughout the study. Knowledge was socially constructed and enabled within the ILE, embedded in classroom participatory practices, social organisation, and integration with prior understandings (Cowie et al., 2013; Smith & Stein, 2011; Staples, 2007).

To explore the social systems that underpinned the ILE, opportunities for participation within this learning community can be examined through the lens of Holland et al.'s (1998) ecologies of participation framed as "figured worlds, positioning, and the space of authoring" (pp. 271-272). In viewing the ILE as an interconnected ecosystem, the "figured world" (p. 41) is where students collectively construct meanings through "mutual engagement, shared repertoire [and] joint enterprise" (Boylan, 2010, p. 5). In this learning community, the figured world was a place where roles were enacted, interpretations made, and actions undertaken (Boaler & Greeno, 2000). On the walls, collectively constructed group norm posters for mathematics were displayed. Students were expected to actively listen, ask questions, repeat ideas, and persevere when challenged. This is important as "perseverance and effort correlate directly with success" (Rollins, 2014, p. 128). Observations showed students working together, recording group members' thinking into large scrapbooks or onto digital devices (for example, Chromebooks), affording value to all students' ideas while, secondly, creating a shared resource that encompassed collective student strategies and thinking.

Observations of the ILE as a busy learning space—one that used not only teachers but other students as resources for learning—aligns with concepts of “positioning” (Holland et al. 1998, p. 126) where identities are developed through the daily routines and social practices underpinning the environment. In the ILE, multiple mathematics activities were undertaken during mathematics sessions, meaning roles varied and authority was distributed. Research findings (for example, Attard, 2012; Boaler, 2016) suggest continued, varied social interactions and diverse groupings, engage students in learning mathematics. The “space of authoring” (Holland et al., 1998, p. 170) connected to the way students were afforded opportunities to act and respond within their environment—be it as passive receivers or active participants.

However, in their research into student learning opportunities in mathematics Gresalfi et al. (2012) highlight that although teachers may present opportunities for mathematics learning, it does not mean these opportunities will be recognised and acted upon. They argue norms that underpin mathematics classrooms are influential in shaping “dynamic intention” (p. 253)—that is, students’ understandings and interpretations of what it means to do mathematics. In fact, they suggest differences in student learning may actually align with how students realise and act upon the opportunities afforded.

In this discussion, I have already outlined opportunities for student agency afforded within the ILE through choices and self-initiated activities. However, another aspect that promoted positive interactions within the environment was the affordance of time. Students were often observed to continue with tasks carried over from the previous day, like opening a novel at the bookmarked page, without starting afresh. Eliminating time pressures opens up opportunities for deeper mathematics thinking (Boaler, 2016). As the study progressed, students were observed utilising time to gain understanding, not just to get an answer.

However, developing a mathematics learning community in the ILE was not without its challenges. Students brought contrasting views and identities on what mathematics learning looked like. Some students, used to learning independently, were challenged by collaborative practices and ways of working that underpinned the ILE community. As Teacher Anna mentioned:

> Some students were a bit anti at the start because it was different; we were doing things differently and for some people change is difficult. We found collaborative work was ending up on pieces of paper, and it was frustrating to keep it organised. So, we bought collaborative scrapbooks and put tabs with names out the side so it didn't matter which book they used and so we could track it easily. They found that really challenging because they just wanted their own book …

Participation and ways of working that underpinned the ILE learning community occurred in varying forms. Mathematics sessions occasioned combinations of independent, pair, small group, and whole class grouping structures, promoting participation for students in varying situations. Observations and interviews showed how, over time, students were developing more purposeful mathematical participation patterns aligning to the classroom norms. As students become increasingly able to make mathematical meaning in ways that made sense to them, they gained confidence, finding "new ways-of-being in mathematics" (Klein, 2002, p. 70). Classroom expectations and practices were influential in shaping students' mathematical identities and an appreciation of mathematics that goes beyond the classroom.

5.5 Summary

In summary, this chapter has outlined the four salient themes that emerged from the research: the affordances of spatial arrangement, student agency, students leading the learning, and a mathematics community of learners. Each theme has woven within its composition a complex network comprising the varied opportunities afforded to students when learning mathematics within this ILE. These themes merge the flexible spatial constructs of the ILE with the development of student agentic behaviours, fundamental in placing students as actively engaged participants and central to directing their mathematics learning.

The following chapter—Chapter 6—outlines the five important conclusions that have arisen from this research study.

Chapter 6: Conclusions, Implications, and Opportunities

The purpose of this study was to explore the opportunities afforded to students when learning mathematics in a newly established ILE. In addressing this overall aim, the research focused on (i) the way teachers set up the ILE to promote opportunities to learn mathematics (see 4.3, 4.4, and 5.3); (ii) the ways Year 7 and Year 8 students described and perceived their mathematics learning opportunities in an ILE (see 4.5, 4.6, and 5.2); (iii) the perceived opportunities to learn mathematics in an ILE compared to single-space learning environments (see 4.6 and 5.1); and, (iv) how the spatial elements of the ILE were used to support the learning of mathematics (see 5.1 and 5.4). In addressing the study's main research question: *What can be learned about the mathematical opportunities afforded to Year 7 and Year 8 students in a newly established ILE?* this chapter draws together the research findings (Chapter 4) and discussion (Chapter 5) in the form of a series of conclusions that illustrate the opportunities afforded to students within the ILE.

Focusing on an emerging ILE as a case study, this research gathered data through teacher interviews, classroom observations, and student focus group interviews in coming to understand the ILE as a lived and evolving mathematics learning community. As this research is a small-scale study, it is beyond its scope to present all the complexities of mathematics learning in an ILE. However, the research into this ILE set up, its evolution, and the interactions between people and spatial elements offer insight into how this particular ILE afforded mathematics learning opportunities. Instead of diluting the case study by making generalisations—and reporting the "uninteresting or mundane" (Thomas & Myers, 2015, p. 6)—"case study research offers understanding presented from another's 'horizon of meaning' but understood from one's own" experiences (Thomas & Myers, 2015, p. 14). It seeks to outline considerations and implications for mathematics learning in emerging and existing ILEs.

6.1 Conclusions

As discussed, in this case study ILE the spatial arrangement and underlying flexible evolving structures were fundamental in providing a base from which students were afforded opportunities to learn mathematics. Based on the findings and resulting themes the following conclusions are discussed.

6.1.1 Conclusion One

ILE spatial arrangements, merged with social and relational affordances, underpinned opportunities for mathematics learning.

This research study demonstrates the importance of allowing teaching and learning behaviours to merge and evolve with the spatial affordances of the ILE. Study findings suggest the ILE spatial set up provided an important foundation and structure from which relational interactions could occur. As Gresalfi, Martin, Hand, and Greeno (2009) argue, student competence in mathematics is not an individual trait but is afforded through interactions and participatory opportunities within the classroom activity system and reflected in ways students take up the opportunities. Within the ILE, teacher participants were reflective; understanding they were not expected to know everything, they were open to evolving and learning alongside the students. This was evidenced in the non-static nature of the ILE set up: it flexed, allowing room for change, presenting options for students and teachers. ILE set up included a longer mathematics lesson time frame (approximately one and a half hours), which encouraged students' engagement in various mathematics activities, practices, and grouping structures. ILE set up also presented varied and complex opportunities for mathematics learning, including accelerated, whole class, and extension groups; multiple focal points; socially constructed mathematics opportunities; and access to varying zones and sub-zones within the ILE space. Research findings suggest spatial set up influenced the underlying nature of mathematics learning in the ILE, affording interactions that supported the (re)creation of identities, beliefs, and ways of doing mathematics.

Of particular value within the ILE was the opportunity to appreciate and explicitly think about space. Research participants appreciated the spaciousness, not in having a space of their own but, instead, accessibility to broader, expanded spaces that they described as presenting more possibilities and options for learning mathematics. The ILE arrangement allowed space to be imagined differently by different students, supporting individual learning trajectories.

Through this case study, findings have captured the ILE as an evolving space, outlining systems that underpinned students' opportunities in mathematics and capturing student descriptions through their lived experiences. Findings from this study outline space as an affordance. However, there would be much value in further research being conducted into ideal student numbers in ILE spaces and the point at which spatial qualities are no longer an affordance.

6.1.2 Conclusion Two

Authentic agentic interactions opened mathematics learning opportunities.

The research findings illustrate how the authentic use of agentic practices placed students as active participants in directing their learning and shaped the (evolving) nature of mathematics within the ILE. This was evidenced in the multiple choices afforded to students through task selection, furniture arrangements, where learning occurred, and conceptual autonomy. However, student choice was still bounded by classroom structures, spatial elements, and routines within the ILE. For example, task choice involved perhaps three options. Student voice influenced mathematical concepts and workshops required, outlining learning direction and positioning students at the heart of the ILE.

The findings of this research demonstrate the importance of affording agency to students in varying and authentic ways. In distributing the authority, students were presented opportunities associated with increased engagement and empowerment. Opportunities were afforded for deeper understanding of mathematical content and concepts, with students actively involved in their learning direction and making connections to prior learning. Importantly, afforded agency was increasingly independently enacted.

However, limitations of the study meant only the voices of the research participants (a subset of the community) were recorded. Further research into student agency in ILE settings could explore aspects, such as: Are the voices of students equal; who is making things happen within the class? (Wagner, 2007); and do the experiences of students in other ILEs match the opportunities these students were afforded? Further research may also help understand affordances that promote deeper reflection and new ways of promoting agentic behaviours in ILE contexts.

An additional limiting factor in this study could be the size of the ILE in that it is comparatively smaller than other ILEs across New Zealand. For example, ILEs may contain three teachers and anywhere from 75 to 100 students (Benade, 2017b; Wilson, 2015) or more.

6.1.3 Conclusion Three

Small group accelerated lessons with one teacher, followed by whole class mathematics sessions based on the same concept, opened space for more equitable outcomes and positive patterns of mathematics participation.

Access to two teachers was described by all participants as positively increasing opportunities to learn mathematics. Organisational flexibility within the ILE allowed different workshops to occur in varying spaces without interruption. Of particular value were the accelerated head start workshops, which proved instrumental in affording more equitable patterns of participation for groups of students. These workshops that offered an introduction to upcoming mathematical concepts were influential in reconstructing students' relationships with, and views of, themselves as learners of mathematics. Students expressed more positive mathematics identities: "I feel happier. If I'm stuck in normal maths time the maths head start helps me a lot, to understand it" (Karl). The accelerated learning groups were important in positioning students as empowered learners of mathematics.

6.1.4 Conclusion Four

Student-led learning integrated and reinforced newly learnt concepts.

Within the ILE learning needs were met through timely workshops, initially led by teachers but, as the year progressed, led by students. Over the course of the study, these workshops evolved with more students positioned as student leaders. By leading learning, students consolidated strategies through explanations to their peers. The flexible spatial arrangements supported multiple small workshops operating simultaneously.

6.1.5 Conclusion Five

The ILE was an evolving learning focused community, shaped and reshaped by and for those within.

Observations in the case ILE showed co-created expectations became integrated within the mathematics ILE community. Distributed authority, opened space in complex ways, both physically and metaphorically. Space was opened for individual student learning but also more broadly for identity, reflection, equity, confidence, and social interactions. Therefore, space was a powerful affordance that presented opportunities for mathematics learning in multiple and complex ways. The ILE was an evolving mathematics community, a lived ecosystem that continually flexed to accommodate change, as it attempted to place students as central to the learning process.

6.2 Going Forward

This study sought to understand the opportunities afforded to students when learning mathematics in a newly established ILE. Prior studies researching primary school students' opportunities when learning mathematics have generally been undertaken in single-space contexts (for example, Gresalfi, 2009; Hunter & Anthony, 2011). Research into student learning in ILEs has most often been from the perspectives of teachers and school leaders (for example, Bradbeer et al., 2017; Byers et al., 2014; Charteris et al., 2018; Deed & Lesko, 2015) or those involved in ILE implementation. By focusing attention on students' perspectives of mathematics learning, this study sets to open space from which the voices of the students, new to learning within an ILE, are afforded their say. Providing a student lens, a sneak peek, a snapshot into the lived experiences of those within the ILE affords an opportunity for others to learn more about mathematics learning within ILEs.

The size of the case ILE for this study was comparatively smaller than most other ILEs across New Zealand, where ILEs may contain 3 teachers and anywhere from 75 to 100 students (Benade, 2017b; Wilson, 2015). Further research that seeks to understand the nature of learning mathematics in much larger ILEs with multiple teachers is also required. Such research may make comparisons within and across cases, exploring how the learning opportunities are similar and differ to those presented in this case study.

In conclusion, is fitting that the last word reflects the student voice—in this instance Madison, as she reflects on learning mathematics within the ILE:

This year, [in the ILE] I see maths differently, not just text books and answers. Maths learning involves my decisions; I choose where I work and what activity I do. I ask myself, what do I need to know next? Then I choose a workshop. I like having time and space to think things through and talk to my teachers and friends about my ideas.

References

Abbiss, J. (2013). Social sciences and '21st century education' in schools: Opportunities and challenges. *New Zealand Journal of Educational Studies*, *48*(2), 5-18.

Abbiss, J. (2015). *Future-oriented learning, innovative learning environments and curriculum: What's the buzz?* Retrieved from http://dx.doi.org.ezproxy.massey.ac.nz/10.18296/cm.0001

Aguirre, J., Mayfield-Ingram, K., & Martin, D. B. (2013). *The impact of identity in K-8 mathematics: Rethinking equity-based practices.* Reston, VA: National Council of Teachers of Mathematics.

Amos, C. (2013). *Modern learning environments and educational technologies*. Retrieved from http://educationreview.co.nz/modern-learning-environments-and-learning-technologies/

Angrosino, M. (2012). Observation-based research. In J. Arthur, M. Waring, R. Coe & L. Hedges (Eds.), *Research methods & methodologies in education* (pp. 165-169). Thousand Oaks, CA: Sage.

Anthony, G. & Hunter, R. (2005). A window into mathematics classrooms: Traditional to reform. *New Zealand Journal of Educational Studies, 40*(1), 25-43.

Anthony, G., & Walshaw, M. (2007). *Effective pedagogy in mathematics/panagrau: Best evidence synthesis iteration (BES)*. Wellington, New Zealand: Ministry of Education.

Anthony, G., & Hunter, R. (2017). Grouping practices in New Zealand mathematics classrooms: Where are we at and where should we be? *New Zealand Journal of Educational Studies*, *52*(1), 73-92.

Ary, D., Jacobs, L. C., Sorenson, C. K., & Razavieh, A. (2010). *Introduction to research in education* (8th ed.). Belmont, CA: Thomson Wadsworth.

Askew, M. (2012). *Transforming primary mathematics*. New York, NY: Routledge.

Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *Australian Primary Mathematics Classroom 17*(1), 9-13.

Barab, S. A., Cherkes-Julkowski, M., Swenson, R., Garrett, S., Shaw, R. E., & Young, M. (1999). Principles of self-organization: Learning as participation in autocatakinetic systems. *Journal of the Learning Sciences, 8*(3/4), 349-390.

Barrett, P., Zhang, Y., Davies, F., & Barrett L. (2015). *Clever classrooms*. Retrieved from https://www.salford.ac.uk/cleverclassrooms/1503-Salford-Uni-Report-DIGITAL.pdf

Bass, H. (2017). Designing opportunities to learn mathematics theory-building practices. *Educational Studies in Mathematics*, *95*(3), 229-244.

Benade, L. (2017a). *Being a teacher in the 21st century*. Singapore: Springer.

Benade, L. (2017b). Is the classroom obsolete in the twenty-first century? *Educational Philosophy and Theory*, *49*(8), 796-807.

Benade, L., Gardner, M., Teschers, C., & Gibbons, A. (2014). 21st-century learning in New Zealand: Leadership insights and perspectives. *Journal of Educational Leadership, Policy and Practice*, *29*(2), 47-60.

Bigger classrooms, bigger problems. (2017, September, 28). *Newsroom*. Retrieved from https://www.newsroom.co.nz/2017/09/27/50283/bigger-classrooms-bigger-problems

Boaler, J. (2014). Ability grouping in mathematics classrooms. In S. Lerman (Ed.), *Encyclopedia of mathematics education* (pp. 1-5). Dordrecht, Netherlands: Springer.

Boaler, J. (2016). *Mathematical mindsets. Unleashing students' potential through creative math, inspiring messages and innovative teaching.* San Francisco, CA: Jossey-Bass.

Boaler, J., & Greeno, J. G. (2000). Identity, agency and knowing in mathematics worlds. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 171-200). London, England: Ablex.

Bolstad, R., Gilbert, J., McDowall, S., Bull, A., Boyd, S., & Hipkins, R. (2012). *Supporting future-oriented learning and teaching: A New Zealand perspective.* Wellington, New Zealand: Ministry of Education.

Boylan, M. (2010). Ecologies of participation in school classrooms. *Teaching and Teacher Education, 26*(1), 61-70.

Bradbeer, C., Mahat, M., Byers, T., Cleveland, B., Kvan, T., & Imms, W. (2017). The 'state of play' concerning New Zealand's transition to innovative learning environments: Preliminary results from phase one of the ILETC project. *Journal of Educational Leadership, Policy and Practice*, *32*(1), 22-38.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology, *Qualitative Research in Psychology, 3*(2), 77-101.

Bray, B., & McClaskey, K. (2013). A step-by-step guide to personalize learning. *Learning & Leading with Technology, 40*(7), 12-19.

Byers, T., Imms, W., & Hartnell-Young (2014). *Curriculum and Teaching 29*(1) 5-19. DOI:10.7459/ct/29.1.02

Cardno, C., Tolmie, E., & Howse, J. (2017). New spaces—New pedagogies: Implementing personalised learning in primary school innovative learning environments. *Journal of Educational Leadership, Policy and Practice, 32*(1/2), 111-124.

Charteris, J., Smardon, D., & Page, A. (2018). Spatialised practices in ILEs: Pedagogical transformations and learner agency. In L. Benade & M. Jackson (Eds.), *Transforming education* (pp. 19-31). Singapore: Springer.

Clarke, D., Roche, A., Cheeseman, J., & Sullivan, P. (2014). Encouraging students to persist when working on challenging tasks: Some insights from teachers. *Australian Mathematics Teacher, 70*(1), 3-11.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). New York, NY: Routledge.

Cook-Sather, A. (2014). The trajectory of student voice in educational research. *New Zealand Journal of Educational Studies, 49*(2), 131-148.

Cowie, B., Otrel-Cass, K., & Moreland, J. (2013). *Expanding notions of assessment for learning: Inside science and technology primary classrooms* [ebook]. Retrieved from http://eds.b.ebscohost.com.ezproxy.massey.ac.nz/eds/ebookviewer/ebook/bmxlYmtfXzU3NjQ0Nl9fQU41?sid=a8e1cbf4-8df8-4e2f-9312-f82a69b4cf28@sessionmgr101&vid=0&format=EB&rid=1

Creswell, J. W. (2009). *Designing research.* Retrieved from http://www.gsic.uva.es/~amartine/thai/readings/Creswell2009_ch7-8-9.pdf

Crow, C. (2015). *Talking mathematics in the MLE: Teacher-student interaction in mathematics in a modern learning environment* (Unpublished master's thesis). University of Auckland, Auckland, New Zealand.

Dane, J. (2016). The effective teaching and learning spatial framework. In W. Imms, B. Cleveland & K. Fisher (Eds.), *Evaluating learning environments* (pp. 211-228). Rotterdam, The Netherlands: Sense.

Deed, C., & Lesko T. (2015). 'Unwalling' the classroom: Teacher reaction and adaption. *Learning Environments Research, 18*(2), 217-231.

Denzin, N. K., & Lincoln, Y. S. (2018). The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE book of qualitative research* (5th ed.; pp. 1-35). Thousand Oaks, CA: Sage.

Dumont, H., & Istance, D. (2010). Analysing and designing learning environments for the 21st century. In H. Dumont, D. Istance, & F. Benavides (Eds.), *The nature of learning: Using research to inspire practice* (pp. 19–34). Retrieved from https://www.keepeek.com//Digital-Asset-Management/oecd/education/the-nature-of-learning_9789264086487-en#.WqSaaxNua3U#page20

Dweck, C. (2012). *Mindset: How you can fulfil your potential*. London, England: Robinson.

Flynn, P. (2014). Empowerment and transformation for young people with social, emotional and behavioural difficulties, engaged with student voice research. *New Zealand Journal of Educational Studies, 49*(2), 162-175.

Foot, K. A. (2014). Cultural-historical activity theory: Exploring a theory to inform practice and research. *Journal of Human Behavior in the Social Environment, 24*(3), 329-347.

Foote, M. Q., & Bartell, T. G. (2011). Pathways to equity in mathematics education: How life experiences impact researcher positionality. *Educational Studies in Mathematics, 78*(1), 45-68.

Garrity, J. (2015). *Learner agency: The missing link.* Retrieved from http://institute4pl.org/index.php/2015/09/14/learner-agency-the-missing-link/

Gasser, K. W. (2011). Five ideas for 21st math classrooms. *American Secondary Education, 39*(3), 108-116.

Gattey, M. (2018, May 2). How modern learning environments work, and what parents' options are. *Stuff*. Retrieved from https://www.stuff.co.nz/national/education/103557339/how-modern-learning-environments-work-and-what-parents-options-are

Gravemeijer, K., Stephan, M., Julie, C., Lin, F., & Ohtani, M. (2016). What mathematics education may prepare students for the society of the future? *International Journal of Science and Mathematics Education, 15*(1), 105-123.

Gresalfi, M., Martin, T., Hand, V., & Greeno, J. (2009). Constructing competence: An analysis of student participation in the activity systems of mathematics classrooms. *Educational Studies in Mathematics*, *70*(1) 49-70.

Gresalfi, M. S. (2009). Taking up opportunities to learn: Constructing dispositions in mathematics classrooms. *Journal of the Learning Sciences*, *18*(3), 327-369.

Gresalfi, M. S., Barnes, J., & Cross, D. (2012). When does an opportunity become an opportunity? Unpacking classroom practice through the lens of ecological psychology. *Educational Studies in Mathematics*, *80*(1-2), 249-267.

Government of New Zealand. (2018). *Vote education—Education and workforce sector-estimates 2018/2019*. Retrieved from https://treasury.govt.nz/publications/estimates/vote-education-education-and-workforce-sector-estimates-2018-2019-html#section-13

Hall, C. (2013). *The impact of new learning spaces on teaching practice* [Literature review]. Melbourne, Australia: RMIT University.

Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K. C., Wearne, D., Murray, H., Olivier, A., & Human, P. (1997). *Making sense: Teaching and learning mathematics with understanding.* Portsmouth, NH: Heinemann.

Hipkins, R., Bolstad, R., Boyd, S., & McDowall, S. (2014). *Key competencies for the future.* Wellington, New Zealand: New Zealand Council for Educational Research.

Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.

Hunter, J., Hunter, R., Bills, T., Cheung, I., Hannant, B., Kritesh, K., & Lachaiya, R. (2016). Developing equity for Pāsifika learners within a New Zealand context: Attending to culture and values. *New Zealand Journal of Educational Studies, 51*(2), 197-225. doi:10.1007/s40841-016-0059-7

Hunter, R. & Anthony, G. (2011). Forging mathematical relationships in inquiry-based classrooms with Pasifika students. *Journal of Urban Mathematics Education 4*(1), 98-119.

Hurd, E., & Weilbacher, G. (2017). "You want me to do what? The benefits of co-teaching in the middle school." *Middle Grades Review, 3*(1), 1-14. Retrieved from https://eric.ed.gov/?id=EJ1154829

Imms, W., & Byers, T. (2017). Impact of classroom design on teacher pedagogy and student engagement and performance in mathematics. *Learning Environments Research*, *20*(1), 139-152.

Imms, W., Mahat, M., Byers, T., & Murphy, D. (2017). *Type and use of innovative learning environments in Australasian schools ILETC Survey No. 1*. Retrieved from http://www.iletc.com.au/publications/reports.

Kazemi, E., & Hintz, A. (2014). *Intentional Talk: How to structure and lead productive mathematical discussions.* Portland, ME: Stenhouse.

King, K. (2018, March 17). *My child is not a guinea pig* [Online forum comment]. Retrieved from https://www.facebook.com/mychildisnotaguineapig/posts/1979516972359034

Klein, M. (2002). Teaching mathematics in/for new times: A poststructuralist analysis of the productive quality of the pedagogic process. *Educational Studies in Mathematics, 50*(1), 63-78.

Knock, A. (2011, June 25). *What's the difference between the "open classroom" of the 1970s and "open space" learning today?* [Online forum comment]. Retrieved from https://anneknock.com

Leadbeater, C. (2006). *The future of public services: Personalised learning.* Retrieved from https://www.oecd.org/site/schoolingfortomorrowknowledgebase/themes/demand/41176645.pdf

Lincoln, Y., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.

MacNamara, C. (1999). *General guidelines for conducting research interviews*. Retrieved from https://managementhelp.org/businessresearch/interviews.htm

Massey, D. (2005). *For space*. Thousand Oaks, CA: Sage.

Massey University. (2015). *Code of ethical conduct for research, teaching and evaluation involving human participants*. Retrieved from http://www.massey.ac.nz/massey/research/research-ethics/human-ethics/code-ethical-conduct.cfm

McLaren, D. (2010). Does theory have any point? *Mathematics in School, 35*(5), 2-9.

McLeod, S. (2009). *Simply psychology*. Retrieved from https://www.simplypsychology.org/piaget.html

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.

Ministry of Education. (n.d.). *Innovative learning environments.* Retrieved from http://ile.education.govt.nz/

Ministry of Education. (2007). *The New Zealand curriculum.* Wellington, New Zealand: Learning Media.

Mishra, P., & Mehta, R. (2017). What we educators get wrong about 21st-century learning: Results of a survey. *Journal of Digital Learning in Teacher Education*, *33*(1), 6-19.

Mulcahy, D., Cleveland, B., & Aberton, H. (2015). Learning spaces and pedagogic change: Envisioned, enacted and experienced. *Pedagogy, Culture & Society*, *23*(4), 575-595.

Murphy, C. (2016). *Making the shift: Perceptions and challenges of modern learning practice* (Unpublished master's thesis). University of Waikato, Hamilton, New Zealand.

Murrihy, L. (2018, May 10). *To MLE or not to MLE, that is the question: An open letter to my colleagues* [Online forum comment]. Retrieved from https://www.futureofeducation.nz

Nelson, E. (2017a). 'It's cool, people your same age being in charge of you.' In R. McNae & B. Cowie (Eds.), *Realising innovative partnerships in educational research: Theories and methodology for collaboration* (pp. 9-19). Rotterdam, The Netherlands: Sense.

Nelson, E. (2017b). Re-thinking power in student voice as games of truth: dealing/playing your hand. *Pedagogy, Culture and Society, 25*(2), 181-194.

Organisation for Economic Cooperation and Development (OECD). (2003). *Definition and selection of competencies: Theoretical and conceptual foundations (DeSeCo): Summary of the final report.* Retrieved from http://www.oecd.org/education/skills-beyondschool/definitionandselectionofcompetenciesdeseco.htm

Organisation for Economic Cooperation and Development (OECD). (2009). *Creating effective teaching and learning environments.* Retrieved from http://www.oecd.org/education/school/43023606.pdf

Organisation for Economic Cooperation and Development (OECD). (2012). *The practitioner guide.* Retrieved from http://www.oecd.org/education/ceri/50300814.pdf

Organisation for Economic Cooperation and Development (OECD). (2015). *Schooling redesigned: Towards innovative learning systems.* Retrieved from https://read.oecd-ilibrary.org/education/schooling-redesigned_9789264245914-en

Organisation for Economic Cooperation and Development (OCED). (2017). *The OECD handbook for innovative learning environments*. Paris, France: Author. https://doi.org/10.1787/9789264277274-en.

O'Reilly, N. (2016). *The key components to creating effective collaborative teaching and learning environments* (Master's thesis, University of Canterbury, Christchurch, New Zealand). Retrieved from http://www.waitakiri.school.nz/site/waitakirischool/2016%20UC%20Thesis%20N%20O%27Reilly%20.pdf

Osborne, M. (2013). *Modern learning environments* [White paper]. Retrieved from http://www.chcheast.school.nz/DataStore/Pages/PAGE_246/Docs/Documents/Property-school%20property%20webpage-MLEs%20mark%20osborne%20apr2013.pdf

Osborne, M. (2016). *Innovative learning environments* [White paper]. Retrieved from http://blog.core-ed.org/files/2017/01/Innovative-Learning-Environments-FINAL-web.pdf

Partnership for 21st Century Learning (P21). (2007). *Framework for 21st century learning.* Retrieved from http://www.p21.org/our-work/p21-framework

Pope, D. C. (2017). *Introduction to qualitative research methods* [Video file]. Retrieved from http://methods.sagepub.com.ezproxy.massey.ac.nz/video/introduction-to-qualitative-research-methods

Punch, K. F., & Oancea, A. (2009). *Introduction to research methods in education* (2nd ed.). Thousand Oaks, CA: Sage.

Rollins, S. P. (2014). *Learning in the fast lane: 8 ways to put all students on the road to academic success*. Alexandria, VA: ASCD.

Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field Methods 15*(1), 85-109.

Saldaña, J. (2013). *The coding manual for qualitative researchers* (2nd ed.). London, England: Sage. Retrieved from file:///Users/Teacher/Downloads/Saldana-2013-TheCodingManualforQualitativeResearchers2.pdf

Schensul, J. J., & Le Compte, M. D. (2013). *Essential ethnographic methods: A mixed methods approach* (2nd ed., Vol. 3). Lanham, MD: Altamira.

Smardon, D., Charteris, J., & Nelson, E. (2015). Shifts to learning eco-systems: Principals' and teachers' perceptions of innovative learning environments. *New Zealand Journal of Teachers' Work, 12*(2), 149-171.

Smith, M. S., Steele, M. D., & Raith, M. L. (2017). *Taking action: Implementing effective mathematics teaching practices in Grades 6-8.* Reston, VA: National Council of Teachers of Mathematics.

Smith, M. S., & Stein, M. K. (2011). *5 practices for orchestrating productive mathematical discussions.* Thousand Oaks, CA: Sage.

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.

Staples, M. (2007). Whole-class collaborative inquiry in a secondary mathematics classroom. *Cognition and Instruction*, *25*(2), 161-217.

Staples, M.E. (2008). Promoting student collaboration in a detracked, heterogeneous secondary mathematics classroom. *Journal of Mathematics Teacher Education, 11*(5), 349-371.

Streb, C. K. (2010). Exploratory case study. In A. J. Mills, G. Durepos, & E. Weibe (Eds.), *Encyclopedia of case study research* (pp. 373-374). Thousand Oaks, CA: Sage.

Sullivan, C. C. (2012). Classroom furniture—The third teacher. *Buildings*, *106*(2), 24.

Sullivan, P., Askew, M., Cheeseman, J., Clarke, D., Mornane, A., Roche, A., & Walker, N. (2015). Supporting teachers in structuring mathematics lessons involving challenging tasks. *Journal of Mathematics Teacher Education, 18*(2), 123-140.

Taylor, S. J., Bogdan, R., & De Vault, M. (2015). *Introduction to qualitative research methods: A guidebook and resource*. Hoboken, NJ: John Wiley & Sons.

Thomas, G., & Myers, K. (2015). *The anatomy of the case study*. London, England: Sage. Retrieved from http://methods.sagepub.com.ezproxy.massey.ac.nz/book/the-anatomy-of-the-case-study/n4.i287.xml

Vosniadou, S. (2001). How children learn. *Educational Practices Series—7*. Retrieved from https://files.eric.ed.gov/fulltext/ED455955.pdf

Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Wagner, D. (2007). Students' critical awareness of voice and agency in mathematics classroom discourse. *Mathematical Thinking and Learning*, *9*(1), 31-50, DOI: 10.1080/10986060709336604

Wahyuni, D. (2012). The research design maze: Understanding paradigms, cases, methods and methodologies. *Journal of Applied Management Accounting Research 10*(1), 69-80.

Wall, G. (2016). *Flexible learning spaces: The impact of physical design on student outcomes.* Wellington, New Zealand: Ministry of Education. Retrieved from www.educationcounts.edcentre.govt.nz

Walshaw, M., & Anthony, G. (2008). The teacher's role in classroom discourse: A review of recent research into mathematics classrooms. *Review of Educational Research, 78*(3), 516-551.

Webb, N. M. (2009). The teacher's role in promoting collaborative dialogue in the classroom. *British Journal of Educational Psychology*, *79*, 1-28.

Wells, A., Jackson, M., & Benade, L. (2018). *Transforming education: Design and governance in global contexts.* Singapore: Springer.

Whyte, B., House, N., & Keys, N. (2016). Coming out of the closet: From single cell classrooms to innovative learning environments. *Teachers and Curriculum, 16*(1), 81-88.

Wilson, M. (2015). *Investigating the effectiveness of modern learning environments on improving student learning and achievement* [Sabbatical report]. Retrieved from file:///Users/Teacher/Downloads/Mark%20Wilson%20Sabbatical%20Report%202015%20-%20Investigating%20the%20Effectiveness%20of%20Modern%20Learning%20Environments%20%20(5).pdf

Yazan, B. (2015). Three approaches to case study methods in education: Yin, Merriam, and Stake. *Qualitative Report, 20*(2), 134-152.

Yeh, C., Ellis, M. W., & Hurtado, C. K. (2017). *Reimagining the mathematics classroom: Creating and sustaining productive learning environments.* Reston, VA: National Council of Teachers of Mathematics.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage.

Appendices

Appendix A: Teacher Interview Questions

Part One. Underlying ILE principles and space

1. So, this is your first year working in an ILE. Talk to me about what you understand are the teaching and learning drivers underlying ILE implementation. (students at centre, social nature of learning).

   What words would you use to describe an ILE?
2. What are the different spaces you have within the ILE and how are they utilised?

   Probes:

- What influenced how your ILE was set up? (physical environment?)
- What would you consider the spatial qualities within the ILE?
- How does this space support learning? (use of break out spaces)
- Who gets to work/learn in particular spaces?
- Who is it that decides? Are there rules/ boundaries in how spaces are used?

3. I notice you have a range of furniture within the ILE (e.g., high tables and stools, low tables and lily pad cushions), How do these physical aspects facilitate learning? (in mathematics)?

   Probes:

- Does the furniture stay put- or is it moved for different activities? Is there anything you would change/add?

Part Two. ILE organisational structures for mathematics

4. In this ILE you work with one other teacher: tell me about what this means in practice?

Part Three. Teaching mathematics in an ILE

5. For mathematics, what kinds of structures have you implemented for:

- Planning?
- Team teaching?
- Rules and expectations?
- What other aspects of organisation have you had to consider? (e.g., do you focus on your 'class?' or are all the students considered both of yours?)

6. Can you tell me about a typical maths session in the ILE? (Tour question) How would it be sequenced? What is your role?

   Probes:

- How is the ILE/class organised for maths lessons?
- How are students within the ILE grouped for maths? (Ability/mixed ability, individual choice)
- What are the norms/expectations within the class? Social interactions? Student accountability? Persistence?
- How are student learning needs met?

7. What ways are students expected to participate during the maths lesson? Can you talk me through the ways in which students communicate (student to student, peer interactions, sharing, whole class discussions?)

   Probes:

- How is maths discussion shared between the students and teacher/s in the ILE?
- What opportunities are there for student collaboration? Student interactions? Student sharing?

8. Please could you describe the types of resources the students can access when learning mathematics? In what ways do they access these? (Where/how/when?). Connections that go beyond the school?

9. What sort of technology do students use in the mathematics lesson?

   Probes:

- How successful is it in supporting learning? How is this organised? (e.g., independent/teacher directed/rotation basis?)

10. To sum up, I would like you think about the changes for mathematics teaching and learning in an ILE compared to a single cell space – and reflect on how these changes are impacting on the students' opportunities to learn mathematics.

Probes:

- Changes in the types of activities - examples
- Changes in who gets to participate in maths - explain
- Changes in the time spent on maths
- Changes in the time the teacher spends with students
- Changes in the agency of students within the mathematics lesson

11. Is there anything else you would like to share/discuss/explain?

Appendix B: Mathematical Learning Opportunities Observational Framework

Date: Time:

Opportunities	Actions	Spatial Qualities	Observations/Comments
Classroom Norms ⇒ Shared expectations ⇒ Interactions that support respect/ learning ⇒ Communication (noise) ⇒ Collaboration ⇒ Independence ⇒ Groupings ⇒ Social interactions ⇒ Boundaries ⇒ Relationships	⇒ Collective understandings ⇒ Persist with challenges ⇒ Equitable ⇒ Groups: who chooses? ⇒ Group size/type ⇒ Across class interactions ⇒ Student choice ⇒ Student interactions with all teachers ⇒ Traffic lights ⇒ Exit tickets	**Spaciousness** ⇒ Use of all space ⇒ Equitable use ⇒ Ease of movement ⇒ Self-created space ⇒ Visual transparency ⇒ Breakout spaces **Accessible Technology** ⇒ Students/teachers **Mobile Furniture** ⇒ Flexibility ⇒ Self-created space	
Participation and Communication ⇒ Participation ⇒ Mathematics discourse ⇒ Asking questions ⇒ Conversations ⇒ Sharing their thinking ⇒ Groupings ⇒ Time spent in groups / individually / as a class	⇒ Student: student: teacher interactions ⇒ Student collaboration ⇒ Justifying ⇒ Equitable participation ⇒ Mathematical discourse / conversations ⇒ Asking questions ⇒ Traffic lights ⇒ Exit tickets	**Mobile Furniture** ⇒ Variety of furniture settings (low, mid, high) ⇒ Variety of activities (individual/group) **Active Surfaces** ⇒ Use of walls, floors, movement of furniture ⇒ Sharing spaces ⇒ Student choice **Spaciousness** ⇒ Use of all space ⇒ Break out spaces	
Making Mathematical Meaning ⇒ Task type and activities ⇒ Investigation, exploration, conjecture ⇒ Procedures/ relations ⇒ Student directed investigation ⇒ Inquiry	⇒ Exploring, problem solving, investigating ⇒ Asking questions ⇒ Generalising ⇒ Use of models, drawings, graphs to show meaning ⇒ Recording, explaining ideas ⇒ Comparing, contrasting ⇒ Conceptual understanding	**Variety of furniture settings** ⇒ for student interaction ⇒ sharing meaning ⇒ student needs **Mobile Furniture** ⇒ Flexible, each reconfiguration ⇒ Collaboration **Accessible Technology** ⇒ To show understanding **Student access to all features** ⇒ Boundaries/Rules ⇒ Break out space access (independent/quiet space)	
Access to Resources ⇒ Horizontal Connectedness ⇒ 'Real World' ⇒ Mathematics tools and resources ⇒ Context ⇒ Teacher/s ⇒ Other students ⇒ Technology ⇒ Inquiry/modelling books	⇒ Beyond school ⇒ Student agency (activity choice, resource choice) ⇒ Access to technology (chrome books, ipads) ⇒ Apps ⇒ Activity choice ⇒ Simultaneously present learning for consideration of others ⇒ Reflection journal	**Accessible Educational Technology** ⇒ Internet, seesaw ⇒ Technology type ⇒ Resources/tools ⇒ Student choice **Active Surfaces** ⇒ For presenting, sharing ideas (How?) Variety of furniture settings ⇒ Different groups on different activities	
'Students at the centre' ⇒ Student agency ⇒ Prior learning (connections) ⇒ Organisational structures ⇒ Accountability ⇒ Sharing learning ⇒ Student choice ⇒ Student voice	⇒ pace ⇒ choice of activities ⇒ Access to resources choice (independent/ dependent) ⇒ Goal setting/ reflection ⇒ Frontloading ⇒ Student decision making over content ⇒ Workshops (choice) ⇒	**Mobile Furniture** ⇒ Variety of furniture settings (low, mid, high) ⇒ Variety of activities (individual/group) **Active Surfaces** ⇒ Use of walls, floors, movement of furniture ⇒ Sharing spaces **Spaciousness** ⇒ Simultaneous activities occurring ⇒ Student choice	

Adapted from The effective teaching and learning spatial framework (p.220-221), by J.Dane (2016).

Appendix C: Code Matrix: connections to teacher interviews, observations, and focus group discussions.

Codes	Teacher interviews	Observations	Focus group interviews
Space Utility *Connections to other codes:* Flexibility/ Fluidity Purposeful, self-selected, open spaces 'Like' ILE space Partner teachers Grouping structures Mobile furniture	**Hine**: different zones; quiet zone, it's device free; break out spaces, group work or workshops; free flowing space; big, not crammed; calm zone. **Anna**: break out space for our target learners. One end of class is a quiet zone, all areas get used at different times and in different ways; warmer weather the deck. It's flexible, no one has a fixed spot where they work. A break out space which really like doubles as our office and a calm zone—bean bags and strategy posters **I#2: Anna**: Different zones for different students, which means that one part of the room, which is partly out of sight is only able	**1x tchr**: Hine breakout space with target group **1x tchr**: Anna rest of class 1x VLN group (indep)- 2 students **Multiple teachers/ partner teachers**: Use of space-wide and varied, continually changing (student choice). No fixed space, movement—fluid use of space, no fixed positions, free movement throughout. VLN maths, doors closed to large zone so students can work use chrome books and interact with the VLN teacher. VLN group moves in and out of whole class programme independently during this time. Space used fluidly over course of lesson-	**Joe**: We have different activities and sometimes we have workshops on so one group will use one room and another group will use the other. **Mia**: I like the bigger classroom, in a smaller classroom it just feels like you are stuck in (wraps arms around herself) with everyone else but with a bigger classroom it can spread out and it's just kind of easier to get more work done. **Vicki**: if we were in one of the other classrooms without a shut off space it wouldn't be as easy to do it (VLN) coz then you'd have the background noises. **Jake**: spread out so you don't have to be confined into a small area.

	to be used during learning time by independent students. We want those ones who have the higher needs to be right by us, not off and around the corner, it's much easier for them to get a bit lost you can't really see- to keep tabs on them.	individual-group-whole class- group for game-whole class-pairs-whole class Head start groups in break out space (acceleration) **6/6/18**: Workshop being conducted in breakout space (8 students) some chosen, some self-selected Zones within the class, classified red, orange and green. Student earn the right to work in specific zones (sub-zones). Multi-purpose spaces and varying zones. Tangible: beans bags, benches and stools. Non-tangible: open spaces, affords flexibility. Opens up active surfaces—students working on the floor, some lying down, others seated on bean bags.	**Ruby**: last year if you wanted to do maths learning in quiet you couldn't really get a space, the whole class would have to be quiet. Here you can shut the doors in the middle, when we are doing VLN and it's pretty much sound proof. **Max**: It's a lot bigger, a lot more space. You can spread out. **Eva**: there is a quiet space, with a break out space which is good because if you are finding it a bit loud you can just go in there and think quietly by yourself or with a group **Madison**: different activities in different spaces with different teachers, presents new possibilities. **Kegan**: I like this space. it's just a bit more comfortable for me, it's all organised.

		Posters with sticky notes and reflections attached to the walls. Self-created spaces—moved bean bags and benches to create own working space. Glass—the transparency opens up spaces.	**Mason**: We get to choose where we work, so we have 4 booths, two in the quiet zone and two in front of the quiet zone. We have the quiet zone with bean bags a small table, we have the high desk which fits two people and another high desk that fits four people coz we put two together- and then we have the pepsi table (red and blue) and the second pepsi table and then we have the little kneel table with the lily pad cushions and we have a break out out space. **Ruby**: I definitely like this year's learning space, it's got a lot of space for different learning and even when there's a small group doing, say, VLN in this part, the rest of the class can still fit in the other side of the classroom. It's a comfortable space.

Appendix D: Request to Enter Institution

Dear

I am a postgraduate student researcher, currently on a New Zealand Teacher's study award, conducting educational research through Massey University to complete my Masters in mathematics education. My thesis will involve the exploration of student experiences and opportunities to learn mathematics in an Innovative Learning Environment (ILE). My research will involve teachers and students in a year 7/8 ILE.

This research will begin with teacher interviews to explore issues related to classroom organisation, and collaborative planning for mathematics within the ILE. The research will then involve eight classroom observations of mathematics lessons (spread across terms 2 and 3) focusing on student participation, communication, grouping and the utilisation of the physical space in the ILE. Following each observation of the mathematics lesson a group of participating students will be interviewed in a withdrawal space at a time that suits the classroom teacher/s and programme. The group interviews will be sound and video recorded to allow student experiences, interactions and voice to be captured.

I would like to request access to undertake my research in your school environment and invite the two teachers, (teacher names) who are working in an ILE this year to be involved. As the Ministry of Education opens more Innovative Learning Environments this research is important in understanding the experiences and opportunities to learn mathematics that are afforded to students.

The research will begin in late term one, through term two and conclude in early term three, 2018. All research will be used for the purposes of this study. All information gathered will be stored securely in locked facilities at my house and will be destroyed after five years. Particular care will be taken to ensure confidentiality by changing the school name and the names of the participants to ensure anonymity.

You are welcome to contact me at [redacted] or alternatively on [redacted].

Yours sincerely,

Maree Logan

Appendix E: Board of Trustees and Principal Information sheet

Dear School Board of Trustees and Principal,

I am a postgraduate student researcher, currently on a New Zealand Teacher's study award, conducting educational research through Massey University to complete my Masters in mathematics education. My thesis will involve the exploration of student experiences and opportunities to learn mathematics in an Innovative Learning Environment (ILE). My research will involve teachers and students in a year 7/8 ILE and will include teacher interviews (audio recorded), 6-8 classroom observations and 6-8 student focus-group interviews (video recorded).

I would like to ask for your consent to conduct this research within an innovative learning environment at your school. The research would begin in term two and conclude in term three, 2018. All data gathered would be used for the purposes of this study. Particular care would be taken to ensure confidentiality by changing the school name and the names of the participants to ensure anonymity.

Research order- data collection

May, 2018
Pre-research 1:1 teacher interviews
Classroom observations and focus group interviews begin.

June, 2018
Classroom observations and focus group interviews continue.

July, 2018.
Classroom observations and focus group interviews conclude.

End of July/ Early August, 2018
Post-research 1:1 teacher interviews

Please note that participation in this research study is voluntary and gives you the following rights:

- withdrawal from involvement in the study during in the first three weeks;

- to ask questions at any stage of the research study;
- to be given access to a summary of the research study findings, upon conclusion;
- to provide information with the understanding that participants' names will not be used, unless permission has been obtained.

If you have any questions regarding this research study you are welcome to contact me email: [redacted] or phone: [redacted]

or alternatively contact my supervisors at Massey University (Palmerston North)

Professor Glenda Anthony
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Dr Peter Rawlins
email : prawlins@massey.ac.nz phone : 06 356 9909 extension 84403

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern B, Application 18/04. If you have any concerns about the conduct of this research, please contact Dr Rochelle Stewart-Withers, Chair, Massey University Human Ethics Committee: Southern B, telephone 06 356 9099 x 83657, email humanethicsouthb@massey.ac.nz

Thank you for considering taking part in this research.

Kind Regards,

Maree Logan

Appendix F: Board of Trustees and Principal Consent form

This consent form will be held for a period of five years.

We have read the information sheet and have had the details of the research study explained to us. Our questions have been answered to our satisfaction. Should further questions arise we understand we can ask these at any time.

We agree to participating in this research study under the conditions set out on this information sheet.

Name: (printed) ____________________________

(principal)

Date: ____________________________

Signature: ____________________________

Email address: ____________________________

Name: (printed) ____________________________

(Chairperson BOT)

Date: ____________________________

Signature: ____________________________

Email address: ____________________________

Please return the completed consent form to Maree Logan by 27 April, 2018.

Appendix G: Teacher Information Sheet

Dear Teacher Participant

I am a postgraduate student researcher, currently on a New Zealand Teacher's study award, conducting educational research through Massey University to complete my Masters in mathematics education. My thesis will involve the exploration of student experiences and opportunities to learn mathematics in an Innovative Learning Environment (ILE). My research will involve teachers and students in a year 7/8 ILE and will include teacher interviews (audio recorded), 6-8 classroom observations and student group interviews (video recorded).

This research will take place throughout terms two and three, 2018 and will be used for the purposes of this study. Particular care will be taken to ensure confidentiality with the school name and the names of the participants being changed to ensure anonymity.

Research order- data collection

May, 2018
Pre-research 1:1 teacher interviews
Classroom observations and focus group interviews begin.

June, 2018
Classroom observations and focus group interviews continue.

July, 2018.
Classroom observations and focus group interviews conclude.

End of July/ Early August, 2018
Post-research 1:1 teacher interviews

I would like to invite you to participate in my study by being part of a pre and post interview inquiring into your experiences in organising opportunities for learning mathematics in an ILE. Each interview will take approximately 30 minutes. I would also like to make fortnightly visits to your class to observe and interview groups of students following their mathematics session. Suitable times for these visits will be discussed and recorded upon acceptance of your consent.

Please note that participation in this research study is voluntary and gives you the following rights:

- withdrawal from involvement in the study during in the first three weeks;
- to ask questions at any stage of the research study;
- you have the right to decline to answer any particular interview question;
- to be given access to a summary of the research study findings, upon conclusion;
- to provide information with the understanding that participants' names will not be used, unless permission has been obtained.

If you have any questions regarding this research study you are welcome to contact me email: [redacted] or phone: [redacted]

or alternatively contact my supervisors at Massey University (Palmerston North)

Professor Glenda Anthony
email : gjanthony@massey.ac.nz phone : 06 356 9909 extension 84406

Dr Peter Rawlins
email : prawlins@massey.ac.nz phone : 06 356 9909 extension 84403

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern B, Application 18/04. If you have any concerns about the conduct of this research, please contact Dr Rochelle Stewart-Withers, Chair, Massey University Human Ethics Committee: Southern B, telephone 06 356 9099 x 83657, email humanethicsouthb@massey.ac.nz

Thank you for considering taking part in this research.

Maree Logan

Appendix H: Teacher consent form

This consent form will be held for a period of five years.

I have read the information sheet and have had the details of the research study explained to me. My questions have been answered to my satisfaction. Should further questions arise I understand I can ask these at any time.

☐ I agree to participate in this research study under the conditions set out on this information sheet.

☐ I disagree to participate in this research study under the conditions set out on this information sheet.

Name: (printed) ______________________________

Date: ______________________________

Signature: ______________________________

Email address: ______________________________

Please return the completed consent form to Maree Logan by 6 May, 2018.

Appendix I: Parent and Caregiver Information Sheet

Dear Parent/Caregiver

I am a postgraduate student researcher, currently on a New Zealand Teacher's study award, conducting educational research through Massey University to complete my Masters in mathematics education. My research project involves the exploration of student experiences and opportunities to learn mathematics in an Innovative Learning Environment (ILE). This research will take place throughout term two and term three in the new ILE in our school and will involve the teachers and students.

I would like to invite your child to participate in my study. This will involve observations of their mathematics lessons, followed by participation in small group discussions about their experiences and opportunities to learn mathematics in an ILE. Occurring about every two weeks in Term 2 and 3, these group discussions will be video and audio recorded allowing me to replay them to review different responses. The discussions will take place as soon as possible, at a time set by the teacher, following the observed mathematics lesson. Approximately six students will be involved in each discussion, with discussions being approximately 10 minutes in duration. Each consenting student might be invited to participate in about 3-4 of these discussions. Particular care will be taken to ensure confidentiality with the school name and the names of the participants being changed to ensure anonymity.

Please note that participation in this research study is voluntary and gives you the following rights:

- To withdraw your child from involvement in the study during in the first three weeks;
- ask questions at any stage of the research study;
- be given access to a summary of the research study findings, upon conclusion;
- provide information with the understanding that participants' names will not be used, unless permission has been obtained.

If you have any questions regarding this research study you are welcome to contact me email: [redacted] or phone: [redacted]

or alternatively contact my supervisors at Massey University (Palmerston North)

Professor Glenda Anthony
email : gjanthony@massey.ac.nz phone : 06 356 9909 extension 84406

Dr Peter Rawlins

email : prawlins@massey.ac.nz phone : 06 356 9909 extension 84403

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern B, Application 18/04. If you have any concerns about the conduct of this research, please contact Dr Rochelle Stewart-Withers, Chair, Massey University Human Ethics Committee: Southern B, telephone 06 356 9099 x 83657, email humanethicsouthb@massey.ac.nz

Thank you for considering taking part in this research.

Maree Logan

Appendix J: Student Participant Information Sheet

Dear

My name is Maree Logan and this year I have the opportunity to be involved in research through Massey University to complete my Masters in mathematics education. My study will involve the exploration of student experiences and opportunities to learn mathematics in an Innovative Learning Environment (ILE).

The Board of Trustees, principal and your teachers have given their consent for this research to occur in your class. During terms two and three I will come into your class (about 6-8 times) and watch a maths lesson. After each of these lessons I would like to ask a group of students to talk about what they did in the maths lesson and how it felt to be working in the new ILE. The teacher will provide us with a space and a time to meet.

These discussions will be about 10 minutes long. They will be video and audio recorded so that I am able to accurately gather your thoughts and experiences. At no time in any of the reporting will your name or any other information that may identify you be used.

I would like to invite you to participate in my study into student experiences and opportunities to learn in your modern learning environment.

Please note that as part of this research you have the following rights:

- to say you do not wish to participate in the study;
- to withdraw from the study in the first 3 weeks;
- to ask questions at any stage throughout study;
- to participate knowing you will not be identified;
- to be given a summary of the study findings at the end of the research.

If you have any questions regarding this research study you are welcome to contact me email: [redacted] or phone: [redacted]

or alternatively contact my supervisors at Massey University (Palmerston North)

Professor Glenda Anthony

email : gjanthony@massey.ac.nz phone : 06 356 9909 extension 84406

Dr Peter Rawlins

email : prawlins@massey.ac.nz phone : 06 356 9909 extension 84403

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern B, Application 18/04. If you have any concerns about the conduct of this research, please contact Dr Rochelle Stewart-Withers, Chair, Massey University Human Ethics Committee: Southern B, telephone 06 356 9099 x 83657, email humanethicsouthb@massey.ac.nz

Thank you for considering taking part in this research.

Maree Logan

Appendix K: Parent / Caregivers and student consent form

This consent form will be held for a period of five years.

STUDENT CONSENT

☐ I agree to ______________________________________ participating in this research study under the conditions set out on this information sheet.

☐ I disagree to ______________________________________ participating in this research study under the conditions set out on this information sheet.

Student's Name: (printed) ___________________________

Student's Signature: ___________________________

Date: ___________________________

PARENT CONSENT

☐ I agree to my child______________________________________ participating in this research study under the conditions set out on this information sheet.

☐ I disagree to my child______________________________________ participating in this research study under the conditions set out on this information sheet.

Parent's Name: (printed) ___________________________

Parent's Signature: ___________________________

Date: __________________________

Please return the completed consent form to Maree Logan by 11 May, 2018.

Appendix L: Observation Consent Form

This consent form will be held for a period of five years.

I have read the information sheet and have had the details of the research study explained to me. I have had my questions answered to my satisfaction. I understand if I have any other questions I can ask these at any time.

I understand that the researcher may use observations from her classroom visits to help with her study but these observations will not include real student names or identifying information.

I agree to the researcher observing my participation in regular classroom mathematics lessons, under the conditions set out in the Information Sheet.

Signature: (student) ____________________________

Name: (printed) ____________________________

Signature: (parent) ____________________________

Name: (printed) ____________________________

Date: ____________________________

Please return the completed consent form to Maree Logan by 11 May, 2018.

Appendix M: Focus Group Consent Form

This consent form will be held for a period of five years.

I have read the information sheet and have had the details of the research study explained to me. I have had my questions answered to my satisfaction. I understand if I have any other questions I can ask these at any time.

I understand that I have a responsibility to respect the privacy of the other members of the group by not talking about any personal information that they share during our discussion.
I understand that the researcher may use comments from the group discussion to help with her study but any comments will not include real student names or identifying information.

I agree to participate in the focus group under the conditions set out in the Information Sheet.

Signature: (student) ____________________________

Name: (printed) ____________________________

Signature: (parent) ____________________________

Name: (printed) ____________________________

Date: ____________________________

Please return the completed consent form to Maree Logan by 11 May, 2018.

Appendix N: Copyright permission to use a figure from Clever Classrooms summary report, HEAD project.

To whom it may concern

I would like to request permission to use a Figure from Clever Classrooms, summary report of the HEAD project, published in 2015, in my Masters thesis.
ISBN: ISBN 978-1-907842-63-4
Internet Address:https://www.salford.ac.uk/cleverclassrooms/1503-Salford-Uni-Report-DIGITAL.pdf
I would like to use the figure on page 15.
The material will not be translated.

About me:
Maree Logan
[redacted]
I am currently completing my Masters in Education through Massey University.
My topic is "Opportunities to learn mathematics in a newly established Innovative Learning Environment."
I request permission to make it available on line in an open access institutional repository.

Thank you very much.
Kind Regards,
Maree Logan

Barrett Peter Wed, Oct 17, 6:59 PM
to me

Dear Maree

That is absolutely fine - with a clear reference of course.

Kind regards

Peter

Prof Peter Barrett
07872 176655
www.cleverclassroomsdesign.co.uk

Appendix O: Copyright permission to use a figure from The OECD Handbook for Innovative Learning Environments.

Confirmation Number: 11757140
Order Date: 10/17/2018

If you paid by credit card, your order will be finalized and your card will be charged within 24 hours. If you choose to be invoiced, you can change or cancel your order until the invoice is generated.

Payment Information

Maree Logan
Massey University
[redacted]
Payment Method: n/a

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