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Talking Mathematics in the MLE:

Teacher-Student Interaction In Mathematics In A Modern Learning Environment

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A thesis submitted in fulfillment of the requirements for the degree of Master of Education

The University of Auckland, 2015.
Abstract

There is a large and growing body of theoretical literature to support the change from single-cell, single-teacher traditional classroom environments to multi-teacher, multi-class ‘Modern Learning Environments’ or MLEs. This change is a common experience for many teachers and students in the current New Zealand educational context. However, at present there is little empirical literature to directly support the suggested benefits of transition to a MLE for teachers and students. This study aimed to assist in eliminating this gap in the research by examining the impact of such a transition on teacher-student interactions in mathematics. The setting was a decile 10 state primary school in the centre of a large New Zealand city. The participants were three Year 4 teachers and 12 Year 4 students aged between 8 and 9 years. Data gathering via teacher observations, student questionnaires, and teacher and student interviews occurred on two occasions. Data were first collected in a single-cell, single-teacher classroom environment and then again seven weeks after transition to a multi-teacher, multi-class MLE. The frequency, duration and types of interaction, and types of feedback were compared. The study found that changes in teacher-student interaction and feedback largely stemmed from substantial differences in teacher practices within the MLE, rather than the physical environment of the MLE itself. This finding is consistent with other literature that suggests the effective use of the physical elements of a learning environment is highly contingent on the pedagogical practices that evolve within it. The finding of decreased interaction with lower-achieving students suggests that particular consideration needs to be given to these students in the process of transition to a MLE. Teacher expectation of greater student agency in the MLE was supported by the findings. However, this raised important implications for those students who are less likely to take initiative or have poor self-regulation skills. The change to a co-teaching situation with larger numbers of students created challenges for teachers, such as greater organisational complexity and reduced knowledge of individual students. Appropriate professional learning and development is suggested to assist teachers to successfully meet these challenges and adequately support students in the process of transition.
Acknowledgements

A dear friend of mine described the opportunity of a scholarship as one of the greatest gifts she had ever received. In reflecting on my Woolf Fisher Lead Teacher Masters Scholarship year, I fully endorse this sentiment. And so my thanks must first go to the trustees of the Woolf Fisher Trust for the gift that has allowed me to devote my time and energy to this thesis. I would also like to thank the staff of the Woolf Fisher Research Centre for sharing their knowledge and expertise: to Stuart McNaughton, Aaron Wilson, Rebecca Jesson, and in particular my supervisors Mei Lai and Kerry Lee - without your guidance and encouragement the journey would have been very different and certainly more difficult. In addition, I must mention Angela McNicholl whose work behind the scenes kept everything on track. I would also like to recognize my fellow scholars – Sam McNaughton, Kerry Boyde-Preece, Gina Hemmingsen and Liz Lapish – for their unwavering positivity and support.

I am very grateful to the Sherwood Primary School Board of Trustees for allowing me to take leave to focus on my studies. Many staff at the school supported me by taking on extra tasks in my absence, but I have to make special mention of Melanie Stewart who ensured that everything went smoothly.

This research would not have been possible without the participant group of teachers and students at my research school who shared their journey into a new MLE with me. I am very appreciative of the time and thought they gave to the process. The willingness of the teachers to open their classrooms and teaching practice to me during a time of great change was a particularly generous gesture.

Finally, the support of my friends and family was vital. I wish to especially thank Kay Penniall for her belief in me. And of course a huge thanks to my husband, David Crow, who never doubts what I am capable of and gives his total support to whatever I choose to do.
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Chapter 1: Introduction

New Zealand is in the midst of a dramatic process of change in the physical landscape of its schools, the transition to ‘Modern Learning Environments’ (MLEs). The basis of the Ministry of Education (MOE) definition is that a modern learning environment must be “fit for purpose in the current time” (Ministry of Education, 2015a, What is a Modern Learning Environment section, ¶ 2). Recognising that most school buildings in New Zealand were constructed between the 1950s and 1970s, the MOE acknowledges that teaching practices and student learning needs have greatly changed since that time. It has embarked on a programme that takes advantage of advances in building materials and technologies to create physical spaces that it believes will cater for these changes (Ministry of Education, 2015b). In May 2015, the term MLE, which had previously been used by the MOE when referring to these spaces, was replaced by the term ‘Innovative Learning Environments’ (ILEs). The MOE’s reasons for the change are that ILE has greater international recognition and that there is “growing discomfort” with the term MLE within New Zealand (Ministry of Education, 2015a, What is an Innovative Learning Environment section, ¶3). However, because MLE was the term in use in New Zealand at the time this research began and for the purpose of consistency, the term MLE will be used throughout this work.

While this research explores the transition to MLEs in the New Zealand context, it is not a phenomenon unique to this country. Similar change is evident in a number of countries, such as Australia, the USA and the UK. The literature review will further examine current thought on MLEs from the perspective of authors in these contexts. Perhaps what is unique to New Zealand, is the degree of government influence that appears likely to result in MLEs becoming the predominant environments in which schooling takes place within an entire public education system. The promotion of ‘Modern Learning Environments’ or ‘MLE’s’ has been a recurring theme within MOE focus groups, reports and policy documents in recent years, to the point where it now lies at the core of current policy initiatives in education in New Zealand. In the MOE’s Statement of Intent 2014-2018, the creation of MLEs is one of six strategic intentions (Ministry of Education, 2014). Schools are required to include MLE upgrades as part of their ‘Ten Year Property Plan’. Such Ministry-approved plans are expected of all school Boards of Trustees (governing boards) as a way of ensuring that school buildings continue to be maintained as well as meeting the space and curriculum needs of the school. In 2010, MLE upgrades became an expected priority for schools to address alongside health and safety projects and essential infrastructure projects (Cooper, 2011; Ministry of Education, 2015b). At this time, a MLE Standard was introduced and schools were expected to adopt this as they became due for reviews of their property funding (Ministry of Education, 2011a).

Apart from the regular cycle of maintenance and upgrades, there are several additional factors that have contributed to increased numbers of school building projects throughout New Zealand in recent years. In spite of a decline in the overall number of schools, new schools continue to open. Some are
in response to population growth in particular areas of New Zealand (Ministry of Education, 2015c). Catering for predicted increase in particular sectors of the school population, such as the growing primary-age population is an additional consideration (Ministry of Education, 2011a). The Christchurch Schools’ Rebuild Programme, announced in November 2013, grew from the needs of schools in the wake of the devastating earthquake that hit the area in February 2011. The programme intends to construct 13 schools (on new sites), rebuild 10 schools (on existing sites), fully redevelop 34 schools and moderately develop 58 schools (Ministry of Education, 2015d). An additional goal within the MOE’s property strategy for 2011-2021 is for the repair or replacement of defective school buildings due to weather-tightness problems, commonly referred to as ‘leaky buildings’ (Ministry of Education, 2011a). The MOE’s property strategy for 2011-2021 outlines targets for both existing and new school buildings to meet the MLE standard (Ministry of Education, 2011a). All plans for upgrades, repair or replacement of buildings are expected to reflect MLE principles (Ministry of Education, 2015e).

The researcher has identified two main drivers that initiate a change to MLEs, which are summarised in Figure 1. In many schools the driver is a physical one - the need for creation, replacement or renovation of buildings according to the MOE determined criteria, as described above. An alternative driver for MLEs that emerges is pedagogical - the development of Modern Learning Practices or MLPs. In some schools the creation of MLEs is described as a response to individual teachers’ preferences for certain teaching practices and the desire to develop an environment to support them (Barback, 2014). In others, MLPs are described as a natural progression from the school’s vision of teaching and learning, which leads to the development of MLEs (Bleasdale, 2013; Lawrence, 2014; Ministry of Education, 2015a; O’Reilly 2015a; Osborne 2014). Both drivers lead to expectations around the interrelationship between MLEs and MLPs. However, specific funding is only provided to support the physical driver, the MLE and not the pedagogical driver, MLP.
Figure 1. Drivers of change to MLEs in the New Zealand context

The researcher’s own school and the participant school in this study are examples of a transition to MLEs initiated by the first driver. Both require leaky buildings to be replaced by new buildings designed according to the MLE standard. For schools like these, the change to MLEs may or may not be matched by a pedagogical commitment to MLPs. The researcher would argue that this situation, where the physical environment is the main driver of change, is likely to produce variable outcomes. Woolner, McCarter, Wall and Higgins (2012) support this argument with the assertion that changes are less likely to occur when there is a top-down approach, stating that change in a school needs to come from the teachers. Fullan (2011) defines an effective driver of change as one that results in measurably better student outcomes. He proposes three criteria by which drivers may be assessed as effective. Firstly there must be evidence that the driver causes whole system improvements. Secondly, the driver must be measurable in practice and results. Finally, there must be a clear case that a particular strategy causes a particular result. In the case of the change to MLEs there is yet to be strong empirical evidence that either driver is effective in producing positive outcomes for students.

At the time of writing, debate as to the motives and methods by which the transition to MLEs is being implemented features in the media. Some school principals and parents raise serious concerns about
the physical spaces, the philosophy behind them and their imposition on schools. They question the value they provide in achieving valued student outcomes and their impact on some students (Gerritsen, 2015; Walters, 2015). An additional concern is the way in which this change is implemented and supported. Schools in the midst of this transition receive additional funding to provide physical resources such as furniture and technology (Ministry of Education, 2015f). However, professional learning to support teachers in the transition must be funded from schools’ existing budgets. The researcher proposes that such professional learning with an emphasis on the types of teaching and learning practices that the environment is designed to support is a priority both before and during the transition to MLEs. Without this, there is at best likely to be no evidence of enhanced learning and teaching, and at worst the possibility of a negative impact on teaching and learning. This proposition is supported by other nascent research in this area (Bissett, 2014; Cooper, 2013; O’Reilly, 2015a).

In this study the researcher chose to follow a group of teachers and students through the transition from a traditional single-space single-teacher learning environment (often called ‘single-cell’ classrooms) to a multi-space multi-teacher MLE. The main research question asked what impact the transition of teachers and students from single-space single-teacher learning environments to a MLE might have on teacher-student interaction (TSI). The intention was to contribute to the ongoing discussion around MLEs and their effectiveness in creating positive outcomes for students. Additionally, the researcher saw a valuable opportunity to gain knowledge that might be used to support her own school in a planned future transition to MLEs.

Chapter 2 outlines the physical elements that define a MLE and explores literature as to the their impact on student outcomes. Theoretical literature around MLPs is examined revealing the proposition that they are the result of a current period of rapid social, economic and technological change in the world. Additionally two key themes about MLEs emerge, that MLPs are student-centred and that MLPs make connections. The impact of MLPs on student outcomes is examined through these two themes. Chapter 2 also explores the centrality of TSI to learning. A theoretical framework that conceptualises TSI according to its function is used as the basis for evaluating the impact of TSI on student outcomes. Feedback interactions are further explored as a key subset of TSI in general. A typology of feedback is selected to assist in identifying the types of feedback shown in the literature as making the greatest contribution to positive student outcomes. Finally literature around the teaching of mathematics shows the importance of high-quality TSI and feedback in this curriculum area.

In Chapter 3 the methodological basis for the study is presented. A problem-based methodology (PBM) framework underpinned the research design and the development of four sub-questions. Reasons for the decision to use PBM and the selection of a mixed-methods approach are outlined in the chapter, as are explanations for the choice of measures. The measures used to gather data were
observations, field notes, questionnaires and interviews. A repeated measures design saw data being gathered on two occasions, once prior to the participant teachers’ and students’ transition to a MLE, and again after a period of seven weeks in the MLE. The procedures for gathering the data and its subsequent analysis are also included in Chapter 3.

Chapter 4 presents the findings of the study. Transition to the MLE had a noticeable impact on TSI and feedback that was evident across all data sources. Changes to the duration, frequency and type of TSI and feedback were found. Some student sub-groups were shown to be more affected by the transition. Teachers and students perceived changes to the context and focus for TSI and feedback. Teachers also noted TSI as more likely to be student-initiated. Both teachers and students perceived increased individual time and greater access to teachers as an enabler to TSI and feedback. However, greater student numbers provided a barrier by limiting in-depth knowledge of individual students while contributing to increased complexity of planning and organisation. Students saw changes to organisational TSI resulting in the creation of individual student timetables as an enabler. Additionally, some students identified greater homogeneity of groups in the MLE as an enabler, by creating a more specific instructional focus and a decrease in distractions.

Finally, in Chapter 5 key findings to emerge from the study are discussed. A number of implications of this research are suggested for consideration by schools planning a transition to MLEs. A range of related areas for worthwhile future investigation are outlined as emerging from this study.
Chapter 2: Literature Review

To better understand the impact of the transition of teachers and students from single-space single-teacher learning environments to a MLE, this literature review explores the definition of a MLE. Previous literature considering the impact of the elements of MLEs on student outcomes is identified. As the study examined the impact on TSI, the review elaborates on the concept of TSI and explores literature about the influence of types of TSI on student outcomes.

The Modern Learning Environment defined

Despite being a current feature of educational change both in New Zealand and in other countries (Australia, United States, United Kingdom) the definition of what constitutes a MLE remains fairly broad. Definitions of a MLE appear to draw heavily on the model of a learning environment proposed by the Organisation for Economic Cooperation and Development (OECD) in 2013. It identifies four elements: learners, educators, content, and resources (including space and digital resources). These elements are linked by organisation and pedagogy, allowing for the relationships and dynamics that are encapsulated in a learning environment (OECD, 2013). The OECD model is shown in Figure 2.

The MOE website created to support the strategic intention of developing MLEs echoes the OECD model, stating that a learning environment is “the complete physical, social and pedagogical context in which learning is to occur”. Furthermore, to be considered ‘modern’ the environment must be one that “reflects and supports what is current in terms of pedagogical practice” (Ministry of Education, 2015a). This definition suggests that the MLE cannot be simply defined in terms of a physical space. It is intrinsically linked to pedagogical practice. Additionally the definition suggests that a key component of the MLE is its ability to adapt in response to changes in pedagogical practice over time. In this way it has the capability to be modern for a longer period. Within this review, the current typical physical and pedagogical elements of the MLE will be described and their impact on students explored.

Physical elements of MLEs

The physical features of the MLE provide a dramatic contrast to the traditional single-cell classroom of the past where one teacher worked with a group of 20 to 30 students in relative isolation. The literature on physical design of MLE spaces concurs that they are typically relatively open, able to be easily reconfigured, provide choice in where learning might take place depending on the needs of the learner, include innovative options in furniture and fittings and are supported by a range of technologies (Armstrong, 2014; Blackmore, Bateman, Loughlin, O’Mara, & Aranda, 2011; Ministry of Education, 2015e; Osborne, 2013; Pearlman, 2006).

The types of spaces that make up the MLE are markedly different from those of a traditional classroom. This can be illustrated using the spatial typology constructed by Dovey and Fisher (2014) that classifies learning spaces into six categories. These are described in Table 1.

Table 1

<table>
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<th>Type of space</th>
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<tr>
<td>Classroom</td>
<td>A traditional closed learning space of 40-60m² for 20-30 students. If learning spaces are fully ‘closeable’ to this size then they are classified as classrooms.</td>
</tr>
<tr>
<td>Commons</td>
<td>A learning space of &gt;40m² that cannot be fully closed into a 25 student classroom, is not the major access route to any other commons or classroom, hence protected from major through traffic.</td>
</tr>
<tr>
<td>Streetspace</td>
<td>An open learning space &gt;3m width, cannot be closed into a classroom, is exposed to major through traffic as the primary access space to other learning spaces.</td>
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Meeting area: A small learning area of <40m² accommodating groups of 5-20. The key criterion is that they cannot house a traditional class size.

Fixed function: Any learning space fitted for specialized use such as ‘Arts’, ‘Wet Area’.

Outdoor learning: Any outdoor area defined as an integral part of the learning cluster, generally labelled ‘outdoor learning’, or ‘outdoor room’. Simple access to the outdoors does not qualify.


Traditional learning spaces are generally representative of the classroom category in this typology. In contrast, the MLE tends not to include any spaces of the classroom category. The equivalent total space for several traditional classrooms is combined and reconfigured into spaces that fit the other categories of the typology. This is further illustrated in Figure 3 which shows a floor plan similar to that of a soon to be constructed New Zealand primary school MLE.

Figure 3. Example of floor plan for a primary school MLE

The MLE in Figure 3 is designed for two teams of three teachers, each team having a commons area. The two commons are linked by streetspace that can be closed off. Each team has access to a number of meeting areas, as well as fixed function space designated for ‘wet areas’ and a ‘media space’. Part of the surrounding deck is designated an ‘outdoor learning space’. The plan reflects typical characteristics of an MLE with no traditional classroom spaces, very few internal walls, the
ability to close off or open up areas as required, clustering of multiple teachers and their students in learning hubs, and the provision of dedicated spaces for creative activities. In addition, although not shown in the figure, the plan makes extensive provision for digital technology with a large number of electrical connections and data access points.

Impact of physical elements of MLEs on student outcomes

Perhaps because they are a relatively recent phenomenon, there is little empirical evidence of the direct effects of the physical elements of the MLE on learners (Blackmore, Bateman, Loughlin, O’Mara, & Aranda, 2011). Such effects are likely to be difficult to quantify because of the complex interactions between space, people, systems and pedagogy that are inherent in the learning environment (OECD, 2013). However, there is research on physical elements of learning environments in general. In addition, certain individual characteristics of the MLE - flexibility, openness, and access to technology resources - were considered in prior studies.

Impact of the general physical environment on student outcomes

Overall, there is consensus that physical environments impact on teaching and learning and therefore student outcomes, both achievement and behaviour (Earthman, 2002; Fisher 2001; Young, Green, Roehrich-Patrick, Joseph, & Gibson, 2003). Higgins, Hall, Wall, Woolner and McCaughey (2005), from an extensive review of international literature, conclude that there is strong, consistent evidence of the effect of basic physical variables on learning. However, they qualify this by saying that once minimal standards are met, evidence of the effect of changing these basic physical variables is less significant. Additionally, there is a large variation of opinion and often conflicting claims as to the type and degree of such effects (Woolner, Hall, Higgins, McCaughey & Wall, 2007). A noticeable difference between these earlier reviews and the studies they considered, and more recent ones is the type of elements of the environment that were evaluated. While earlier literature tends to limit its focus to elements such as air quality, lighting, temperature, and noise, more recent studies consider a wider set of physical factors (Barrett, Zhang, Davies & Barrett 2015; Barrett, Zhang, Moffat & Kobbacy, 2013). Barrett, et al. (2013) identified six design parameters that affected rates of progress of students, being light, choice, flexibility, connection, complexity and colour. This study used data from 751 primary-aged pupils across seven schools in the UK. It was followed by a larger three-year study of 3766 primary school students where a multi-level modelling process was used to isolate the effects of physical factors on student achievement (Barrett et al., 2015). This most recent work is of particular interest in that it claims to have quantified the combined impact of the physical characteristics of classrooms on student achievement, as well as identifying the degree of impact of individual factors. Sixteen percent of the variation in learning progress for students was attributed to physical characteristics of classrooms. It was estimated that naturalness (light, temperature and air quality) accounted for around half of this impact. Appropriate level of stimulation (complexity and colour) and individualisation (ownership and flexibility) were each claimed to be responsible for one-quarter of the impact on learning. Interestingly,
the types of physical parameters explored in these two UK studies tend to closely match many physical features considered typical of the MLE.

**Impact of flexibility on student outcomes**

Proponents of MLEs see flexibility of space as being a major benefit as it allows teachers and students to respond agilely to inevitable and unanticipated future changes by easily changing the configuration of the environment. Flexibility of space is said to enhance learning through the provision of more zones, which permits varied learning activities to occur at the same time. It offers greater choice, allowing teachers and students to select a space most suited to the task and their needs (Barrett et al., 2013; Barrett et al., 2015; Higgins et al., 2005). Empirical studies in support of the contention that flexible space leads to improved student outcomes are few. However, the results of those that exist suggest a strong link.

Two recent UK studies that showed links between the physical environment and student outcomes (Barrett et al., 2013; Barrett et al., 2015), both identified flexibility as an influential environmental element. The 2013 work of Barrett et al. included flexibility as one of eight environmental factors that displayed significant positive correlations with pupil’s learning progression, and was one of six they described as particularly influential. In the 2015 study by Barrett et al., flexibility, when combined with ownership as part of the element of individualisation, was calculated to make up 25% of the impact on student learning. However, both studies chose to downplay the possibility of bias being introduced through the effect of teachers on a factor. Barrett et al. (2013), while acknowledging that teachers make decisions about the arrangement of the physical classroom environment, did not explore the possible impact of teachers’ use of that arrangement. However, other evidence suggests that this may be an important consideration.

It has been claimed that simply allowing for flexibility is insufficient. Teachers’ attitudes and behaviour are vitally important to the flexible use of space (Higgins et al., 2005; Rivlin & Rothenberg, 1976). Rivlin and Rothenberg’s (1976) repeated observation and tracking of teachers showed that over time the physical layout of space and patterns of teacher location and movement remained largely unchanged, in spite of being encouraged to be more flexible by the policies of the school and the layout of the classroom. It seems that flexibility may contribute to positive student outcomes, but to do so its affordances must be fully used by teachers to better meet the specific needs of learners and particular learning activities.

**Impact of open space on student outcomes**

A previous model of open learning spaces is the ‘open plan’ classroom that proliferated in the 1970s. There is mixed empirical evidence as to the effects of these open environments on student outcomes. Two meta-analyses considering open classrooms both found little support for their benefits in relation
to academic achievement (Giaconia & Hedges, 1982; Hattie, 2009). Although they believe that open education programmes can produce greater self-concept, creativity, and a positive attitude towards school, Giaconia and Hedges (1982) saw little evidence for greater academic achievement. In Hattie's 2009 meta-analysis, the 'open vs. traditional' school environment was calculated to have an effect size of 0.01. This suggests that a change to more open space may produce little effect on student achievement. However, evidence of enhanced student achievement is found in some individual studies (New Zealand Department of Education, 1977; Jang, 2006; Welch, 2000). In a New Zealand study on open plan classrooms (New Zealand Department of Education, 1977) at least half the teachers considered their students’ achievement in spoken language, reading, mathematics and science to be greater or much greater in an open plan classroom. Researchers commented that the overall positive impression of student achievement was of a degree that could not be ignored. This was in spite of concerns over accuracy of the data as it was gathered by questionnaire. A recommendation that the research should be backed up by data from standardised testing was not acted on. An indirect positive impact on student achievement might also be inferred from the almost 60% of teachers in open plan classrooms in this study who thought that they had greater or much greater opportunities for interaction between themselves and pupils. Welch (2000) and Jang (2006) both make claims for improved student achievement in open plan classrooms. However, these claims must be considered in light of the fact that both were small-scale studies, each working with only two teachers and their students. A second consideration is that the context for the studies was markedly different to the MLE - Welch focusing on learning disabled students and their classmates in the US, and Jang on team-teaching with secondary school mathematics students in Taiwan.

Just as the affordances of flexibility appear to be largely dependent on teacher practices, it seems that openness too is a physical element that may have benefits if used well by teachers. This possibility is raised by Dovey and Fisher's (2014) comments on the past perceived failure of open plan classrooms. They suggest that open plan classrooms were seen as unsuccessful in part due to their being designed for new constructivist educational pedagogies that had not yet become embedded in teaching practices on a widespread basis. Therefore, the MLE has potential to be a more successful model of an open plan environment, should it be aligned with current teaching practices. Additionally, Dovey and Fisher state that in the past when teachers did attempt to adopt more student-centred practices, these largely open spaces were not sufficiently flexible to provide for them. This suggests that provision of flexibility alongside open space in the MLE may have the ability to counteract previous drawbacks of open plan environments.

Impact of access to resources (particularly technology) on student outcomes
Proponents of MLEs advocate for their ability to provide improved access to resources, arguing that shared space allows for shared use of resources, such as technology, that may be too expensive to allocate to every classroom in a traditional single-cell configuration (Osborne, 2013). In addition the
MLE is generally conceived of as a technology-rich learning environment (Ministry of Education, 2014, 2015e; “The network for learning”, 2012). Some authors believe access to technology is an important component of a successful learning space, giving equal weight to it as other components such as space and pedagogy (Radcliffe, 2009; Radcliffe, Wilson, Powell & Tibbetts, 2008). However, when evidence across a wide range of international studies is drawn together, the claims for a link between access to technology and positive student outcomes appears relatively modest. The need for caution in making such claims is supported in the meta-analysis conducted by Higgins, Xiao and Katsipataki (2012). While they believe that studies over 40 years consistently identify positive benefits in the use of technology, they conclude that “.... the correlational and experimental evidence does not offer a convincing case for the general impact of digital technology on learning outcomes” (p. 3). Similar conclusions were reached by Cheung and Slavin (2010), who when reviewing studies as to the effects of educational technology in the learning of mathematics, found small but positive benefits (effect size = +0.15). The ubiquitous nature of digital technology in schools, in particular the interest in providing 1-to-1 access to laptops or devices has given rise to a number of empirical studies of such technology rich-environments (Cavanaugh, Dawson, & Ritzhaupt 2011; Harris & Al-Bataineh 2015; Huang & Russell, 2009; Lowther, Ross & Morrison 2003; Warschauer, 2008). These studies had a high degree of commonality in that they examined K-12 students in the USA, and most used experimental and control groups. However, the findings of these studies represent a continuum from the very guarded claims of Harris and Al-Bataineh (2015) - “1:1 Technology could be a factor in student academic achievement and motivation to be at school” (p. 579) - to the strongly positive findings of Lowther, Ross and Morrison (2003) who state “Writing assessment results showed substantial and significant advantages for laptop over control students, with six of eight effect sizes exceeding +0.80” (p.23). An explanation for the differences in these findings may lie in the consistent references to numerous other factors that impact on the efficacy of technology in raising achievement (Cavanaugh, Dawson, & Ritzhaupt 2011; Cheung & Slavin; Harris & Al-Bataineh 2015; Huang & Russell, 2009). These findings are perhaps best summed up by Huang and Russell (2009) who state “... the relationship between technology, accessibility and academic achievement may also exist, although it is complicated by other compounding factors, such as the subjects of learning, the uses of technology, and socioeconomic conditions” (p. 170). In particular the importance of pedagogy that supports effective use of technology is evident in their proposition “It seems probable that more effective schools and teachers are more likely to use digital technologies more effectively than other schools” (p.3).

In summary, the weight of evidence suggests that the physical elements of a learning environment do impact on student outcomes. There is also evidence that the physical characteristics typical of the MLE, that is spaces that are open, flexible, and technology rich, may contribute positively to student outcomes. However, much of the literature qualifies these claims, advocating that provision of these physical elements alone is insufficient, and that they are more influential for some student outcomes than others. The importance of pedagogical practice that supports effective use of the physical
elements is a consistent theme in the literature. Therefore it is essential to examine the non-physical elements of the MLE, that is the teaching practices considered typical within it.

**Pedagogical elements of MLEs - Modern Learning Pedagogy and Practice**

*MLP and 21st century learning - a new educational paradigm?*

Teaching practices described as being typical of MLEs are often referred to as ‘Modern Learning Practices’, or ‘Modern Learning Pedagogy’ both being denoted by the abbreviation MLP. These terms appear to be used interchangeably, depending on preference of the writer (O’Reilly, 2015b; Osborne, 2013; Osborne, 2014; Wilson M., 2015). Closely related to MLP are widely used terms such as ‘21st century learning’ (Bull & Gilbert, 2012), ‘21st century learning skills’ (Trilling & Fadel, 2009), and ‘21st century competences’ (OECD, 2013). Much of the theoretical literature suggests employing MLP as a way of meeting the challenges of learning in the 21st century. Both MLP and 21st century learning are terms that attempt to draw a line between the teaching practices of the past and those currently in schools. Some would argue that this line is blurred by the fact that many of the practices discussed under the MLP umbrella are long known as effective (Fullan, 2013; O’Reilly, 2015b). From this perspective MLP might simply be the natural evolution of effective teaching practices. However, it can be argued that a unique combination of factors at this time in history have contributed to something of a watershed in education (Bull & Gilbert, 2012; Fullan, 2013). Bull and Gilbert (2012) claim that the major body of literature that has grown up around 21st century learning, is in response to an international paradigm shift in thinking about education. They see this shift as driven by growing awareness of dramatic changes taking place in the world. A period of social, economic and technological change has resulted in massive growth in human knowledge, leading to substantial changes in education. They propose two key drivers of educational change and there is support for their proposition from other authors.

The first driver is that we are in a period of transition from an ‘Industrial Age’ to a ‘Knowledge Age’ (Bereiter, 2004; Bull & Gilbert, 2012; Gilbert, 2007; Hargreaves, 1994; Robinson, 2008). Fullan (2013) describes this period of transition as one in which a synergy between new pedagogy, new technology and new change knowledge will transform education.

For much of recent history our educational practices were based around supporting the needs of an industrialised society. However, the knowledge, skills and dispositions that learners require for the 21st century world are dramatically different. This can be seen in Wagner’s (2010) list of the ‘survival’ skills that are needed to be successful in this post-industrial world - skills such as critical thinking, problem solving, initiative, entrepreneurialism, curiosity and imagination. It is proposed that there is an urgent need to reconsider how we provide opportunities for learners to acquire such skills (Carr & Claxton, 2002; Gilbert, 2007; Papert, 1999).
A second driving force is the knowledge we now possess about how learners learn. This has come from a greater understanding of the brain itself, made possible by technological advances in neuroscience (Bull & Gilbert, 2012; Fullan, 2013; Osborne, 2013). According to Medina (2008), traditional classroom environments that were created for the ‘industrial age’ style of education are greatly at odds to ideal conditions for the brain to function. Another influence on current thinking about learning is the evolving definition of the concept of intelligence. Rather than referring to intelligence as a single quantity that can be measured by one tool such as the traditional IQ test, it is proposed that there are numerous overlapping and equally valid aspects to intelligence (Costa & Kallick, 2000; Gardner, 1983, Lucas & Claxton 2010). Additionally, it is proposed that intelligence is not a fixed entity, but rather something that with the right conditions can grow and change. This theory of what is termed ‘incremental intelligence’ presents new challenges for teachers and learners, particularly in the areas of motivation and engagement in learning (Claxton, 2002; Dweck, 2006; Lucas & Claxton, 2010).

Internationally, there seems to be a broad general agreement that there are - and should be - changes occurring in education as a natural response to our rapidly and dramatically changing world. If we accept this premise, it seems that the elements that define MLP or 21st century learning may well be the face of this new educational paradigm. This study focused on TSI, a construct firmly rooted in the area of teacher practice. Therefore it was decided that where the term MLP is used within the remainder of this work it would be most appropriate to use this abbreviation to represent the term Modern Learning Practice. A logical next step might be to ask what are the key elements of MLP? Within the literature around this question there seems to be high degree of shared support for two major themes: MLP is student-centred, and MLP makes connections.

**MLP is student-centred**

The first theme that dominates the literature on MLP is placement of the student at the centre of learning and assessment. A helpful definition of student-centred learning might be derived from Cornelius-White (2007) who considers learner-centred models to be those where a focus on student variables and learning processes is considered critical to positive student outcomes. These elements are embedded in the pedagogical principles for the creation of effective learning environments (Fisher, 2005; Ministry of Education, 2007, 2015a; OECD, 2013).

One feature of student-centred environments is their ability to provide for individual differences reflecting students’ needs, backgrounds, perspectives and interests through being more personalised (Fisher, 2005; Ministry of Education, 2007, 2015a). Such environments are described as being highly attuned to the motivations and emotions of learners (OECD, 2013). Additionally the environment should be challenging for each learner without creating overload (Fisher, 2005; OECD, 2013). Personalised learning and differentiated learning are key elements of student-centred learning that
have been considered to exemplify quality learning in a modern context (Osborne, 2013). Differentiation encompasses individualised goals, content, and learning methods, and assessments designed to suit individual learners’ needs. This is in contrast to the industrial age model where all students receive the same forms of instruction and assessment (Prankerd & Lockley, 2011). Greater access to digital technologies is claimed to support student-centred learning in that it allows for a more personalised curriculum (Hampson, Patton & Shanks, 2015).

A second feature of student-centred environments is that learners are involved in shaping both content and direction of their learning. It is claimed that extensive research has found that students learn best when they are actively involved in decision making and initiating learning (Ministry of Education, 2007). In New Zealand, student-centred pedagogy is considered to be at the heart of the New Zealand Curriculum (Ministry of Education, 2007, 2015a). Amos (2013) writes from the perspective of deputy principal at a new school designed as a MLE. She describes her hope that the MLE will support more student-centred effective pedagogy as defined in the NZC by discouraging an emphasis on teacher-led instruction while encouraging a more facilitative style of teaching and learning. Student-centred learning presumes learners are in control and have the confidence to initiate and drive their own learning. They develop understanding of how they learn, and co-design the curriculum and their learning environment. Student-centred learning provides opportunities for students to articulate their learning as they co-construct future learning pathways (Ministry of Education, 2015g; Osborne 2013).

These two features of student-centred learning are key tenets of formative assessment or assessment for learning. Black and Wiliam’s (2009) definition of formative classroom practice states that it occurs when “evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction” (p.9). Discussion around MLP refers to the importance of such connections between assessment and future learning (Fisher, 2005; OECD, 2013). The MOE’s position paper on assessment (Ministry of Education, 2011b) describes how assessment for learning is a key concept that underpins teaching and learning in the New Zealand context. The members of the Ministerial Cross-Sector Forum on Raising Achievement identified assessment for learning as an important dimension of a modern learning environment because of its ability to allow for more personalised learning (Ministry of Education, 2012). Sebba, Brown, Galton, Steward and James (2007) go further, describing assessment for learning as a key component of personalised learning. Therefore, there appears to be a strong case for formative assessment practices to be expected in a student-centred learning environment.

**MLP makes connections**

The second theme that emerges in the literature on MLP is that of connection. This theme is expressed in a variety of ways. Firstly there is a focus on building stronger connections between the people within the learning environment. Collaboration between learners is developed through an emphasis on socially constructed learning in cooperative settings (Fisher, 2005; Ministry of Education, 2007; OECD, 2013; Osborne, 2013). Typically MLEs involve grouping of multiple teachers in a shared
space. There is an expectation that teachers will model collaboration by operating in interconnected teams (Gilbert, 2007; Ministry of Education, 2007). Another area of focus is developing greater connections within the content of the learning. Making links within and between learning areas is encouraged (Ministry of Education, 2007, 2015a; OECD, 2013). A third area of focus is the extension of connections beyond the traditional learning environment of the classroom or school. The formation of partnerships between learners and communities beyond the classroom is encouraged. Learners collaborate with parents, family and other outside experts, building strong connections in the process (Fisher, 2005; Hampson, Patton & Shanks, 2015; OECD, 2013). Lessons are expanded beyond the four walls of the classroom and strongly connect to the outside world, both physically and virtually. Learning does not happen in isolation, but within rich, authentic contexts that connect strongly to the world beyond the school gates (Gilbert, 2007; Hampson, Patton & Shanks, 2015; Ministry of Education, 2007; Osborne, 2013). In the New Zealand context, the theme of connection is articulated in the vision of the NZC. It proposes the growing of “confident, connected, actively-involved, lifelong learners” (2007, p. 8).

Impact of MLPs on student outcomes

Impact of student-centred learning

A meta-analysis by Cornelius-White (2007) found an above-average association between learner-centred models and positive student outcomes, and concluded that development of learner-centred relationships is a worthwhile goal. Hattie’s 2009 meta-analysis found similar associations between student achievement and numerous aspects of student-centred practices. Hattie presents particularly strong evidence around practices associated with formative assessment. Key elements of formative assessment, such as the provision of clear learning intentions, specific success criteria and appropriate feedback are cited as being powerful enablers of learning. A seminal author in the field of formative assessment, Wiliam (2011a) supports Hattie’s viewpoint. He believes that there is sufficient theoretical and empirical evidence that formative assessment practices have the power to increase student engagement and improve learning outcomes in ways never seen before.

Impact of connected learning

There is evidence that learning strategies that create opportunities for students to connect with other students result in positive outcomes (Hattie 2009). Notable positive effects on student achievement are noted for strategies involving peer learning, such as reciprocal teaching, pair learning and small group learning, and cooperative and competitive strategies as opposed to individualistic ones (Hattie, 2009; Lou, Abrami & d’Apollonia, 2001).

There are varying opinions offered as to the impact of greater connections between teachers in a
collaborative or team teaching situation on student outcomes. One proposition is that when teaching practice becomes more visible to others, there is greater opportunity for teachers to learn from each other. Sharing of practice where teachers are observed by other teachers and receive feedback from these observations is considered beneficial for student learning (Hattie 2009; Hattie, 2015). However, currently there is a scarcity of empirical research to support the benefits of team teaching for students, largely because it has not been evident in regular school settings (Hattie, 2009). That which exists tends to examine the forms of team teaching that have evolved in more specific contexts, therefore the findings may not be generalisable to the MLE setting. Several studies located in the field of inclusive education have explored team teaching where students with special needs, along with their teachers and teacher aides, were incorporated into mainstream classrooms (Murawski & Swanson, 2001, Rytivaara, 2012; Thousand, Villa, & Nevin, 2006; Walther-Thomas, 1997; Welch, 2000). These authors generally describe positive outcomes such as increases in academic achievement and social skills, stronger peer relationships, improved attitudes to school and greater self-esteem. Similarly, York-Barr, Ghere and Sommerness (2007) found substantial increases in student achievement where collaborative teaching was used to support English language learners in general classrooms. Because they result from extensive large-scale observations of mainstream primary classrooms, the findings of Alexander (1995) and Apter, Arnold and Swinson (2010), are perhaps more applicable to the MLE setting. Alexander (1995), measured factors such as waiting time, patterns of distraction and on-task behaviours in co-taught classrooms. He found that multiple adults in the room did not necessarily produce gains in the amount of time students spent working or an increase in the amount of interaction with a teacher. Alexander suggests that there may come a point where access to more adults either makes no difference or even becomes counterproductive. He cautions that the advantages of having extra teachers may be offset by extra organisational demands, inconsistencies in communication and lack of shared understanding of goals. Similarly, Apter, Arnold and Swinson (2010) found no link between the number of adults in the classroom and on-task behaviour. The lack of evidence to support the effectiveness of team teaching from these studies suggests the need for more research into this aspect of MLEs.

The proposition that greater connection through integration of curriculum subjects will enhance learning has some empirical support. Hattie (2009) reports on meta-analyses from Hartzler (2000), and Hurley (2001), which found some evidence in support of integration. Drake and Burns (2004) refute claims that there is insufficient research to back the efficacy of interdisciplinary learning. They note in addition to Hartzler’s work, other studies showing a correlation between integrated curriculum and high student achievement such as the work of Vars (2001), and Smithrim and Upitis (2005).

The idea of connecting classroom learning to authentic real-world contexts is somewhat linked to the notion of integrated curriculum. Concept-based learning through transdisciplinary themes that makes relevant connections with the world beyond the classroom is thought to enhance the richness of
instructional interactions for students (Curby, Rimm-Kaufmann & Ponitz, 2009). Teaching approaches that encourage such an outward-looking focus include inquiry learning and problem-solving approaches. Research into inquiry learning has its basis in science education. Overall it appears that using an inquiry learning approach over other approaches has a negligible effect (d=0.31) on student outcomes (Hattie, 2009). Problem-based learning, fares even worse, with Hattie’s meta analysis calculating the effect size as d=0.15. However, Hattie qualifies this result, referring to studies that support a claim that while problem-based learning is largely ineffective for surface learning, it has positive effects on deeper learning.

One challenge that emerges for teachers in adopting MLP is a possible tension between the two major themes. The writer perceives that highly personalised programmes developed in response to the theme of student-centred learning risk becoming overly individualised. Such programmes could be detrimental to the co-operative group based learning that one would expect to see in a connected MLE, and that contribute positively to student achievement (Hattie, 2009). By contrast, individualised instruction is noted as having little impact on student outcomes (Hattie, 2009).

Teacher-student interaction

This study chose to focus on TSI because of the integral part it plays in learning and teaching. Leading sociocultural theorists place interaction between the growing human organism and its external world at the centre of their perspectives on learning and development (Bronfenbrenner, 1977; Lave, 1991; Vygotsky, 1986). Bronfenbrenner (1977) proposes a model of human development where interaction of the learner with others is identified as the most direct influence on learning and development outside the individual learner. Lave (1991) similarly locates interpersonal interaction at the centre of the learning process. She proposes that learning takes place as we participate in social practices that are part of the social world that we live within. Vygotsky (1986) describes learning as the result of the interaction between the child and a more knowledgeable (usually adult) other within a ‘zone of proximal development’. He asserts that successful learning takes place within this area of challenge influenced by interaction with a supportive other, such as a parent or teacher. In New Zealand recent developments in curriculum initiatives, initial teacher education and teacher professional development tend to be firmly rooted in such sociocultural theories of learning (George & Bourke, 2008; Hipkins, 2006).

Certainly TSI forms a large part of the daily work of teachers. Galton, Hargreaves, Comber, Wall and Pell (1980) report that primary school teachers are engaged in some form of interaction with pupils for over 78% of the time. Rich, high-quality interaction is consistently positioned as the basis of effective instructional support for students (Brophy & Good, 1986; Curby, Rimm-Kaufmann & Ponitz, 2009;
Hamre & Pianta, 2005; Hamre & Pianta, 2007). Therefore any examination of teaching and learning practices should consider TSI.

**Teacher-student interaction defined**

A definition of what constitutes an interaction is provided by Alexander (1995). He defines a teacher-student interaction as “a complete stanza of conversation between the teacher and an individual, group or whole class of children” (p.134). However, once we attempt to further explore the content and nature of an interaction it becomes evident that it is a complex, multi-faceted construct (McGee & Penlington, 2001). Therefore, it is helpful to impose some structure in order to better understand the construct and its ability to influence learning and teaching. One way that TSI can be conceptualized is according to its function. The Classroom Assessment Scoring System (CLASS) framework developed by Hamre and Pianta (2007) provides such a means of classifying interactions. It has both theoretical and empirical support (Hamre, Pianta, Mashburn & Downer 2007; Luckner & Pianta 2011). In addition to the model being trialled in a large sample (>4000) of standardised observations in preschool and elementary classrooms (Hamre, Pianta, Mashburn & Downer 2007), it was also used as the basis for a number of studies similar to this one (Cadima, Leal & Burchinal, 2010; Curby, Rimm-Kaufmann & Ponitz, 2009). For these reasons, it was selected as the framework to be used in this study. The CLASS framework groups interactions into three domains: emotional support, classroom organization, and instructional support. The conceptual framework is further expanded in Figure 4.

![CLASS Conceptual Framework](image-url)

**Figure 4.** The CLASS conceptual framework for classroom interactions.

**Interactions that provide emotional supports**

Emotionally supportive interactions are the means by which teachers support students’ social and emotional functioning in the classroom (Hamre, Pianta, Mashburn & Downer, 2007). Knowledge of students is paramount if teachers are to interact with students in ways that are perceived to be caring and supportive (McGee & Penlington, 2001). Emotionally supportive teachers use this knowledge to act sensitively towards students, show understanding of their needs, respond to student interests and adapt their teaching in response to the information they gain through reciprocal interactions between themselves and their students (Curby, Rimm-Kaufmann, & Ponitz, 2009; Hamre & Pianta, 2007). For example, a teacher may initiate conversation with a student to enquire about an area of interest outside the classroom, e.g. “How was your ballet performance?”, or to show the student that they recognise challenges they may be facing, e.g. “I know you must be finding it difficult to work with that cold.”

There is evidence that an emotionally supportive classroom climate results in enhanced student outcomes. However, direct links are more likely to be found with personal and affective outcomes. For example, emotionally supportive classrooms are better at nurturing desirable learner traits such as autonomy, independence and willingness to take risks in thinking (Birch & Ladd, 1998; Hamre & Pianta, 2007). Numerous studies demonstrate high correlations between person-centred teacher variables and more positive student attitude, greater motivation and increased engagement (Cornelius-White, 2007; Fraser & Walberg 1991; Goh & Fraser, 1998; Pianta, Hamre & Allen, 2012; Wubbels & Brekelmans, 2012). Less direct, but reasonably compelling links have been made between emotionally supportive environments and student achievement outcomes. Emotionally supportive interactions are the basis for building strong, positive relationships between student and teacher (Luckner & Pianta, 2011). Numerous sources indicate that relationships between teacher and student have a significant positive influence on student achievement, evidenced in Hattie’s 2009 meta-analysis where he calculates the effect size as 0.72. In a New Zealand context, Bishop, Berryman and Richardson (2002), found that students, parents and principals emphasized teacher-student relationships as a major contributor to student achievement.

**Interactions that provide organizational supports**

High quality organisational interactions are generally considered typical of effective teachers (Oliver & Reschly, 2014; Stronge, 2007). Teachers use organisational interactions to proactively manage the time, attention and behaviour of their students and the resources needed to support learning, and so maximise productive learning time (Curby, Rimm-Kaufman & Ponitz, 2009; Luckner & Pianta, 2011). For example, a teacher skilled in organisational interactions will use them to pre-empt possible barriers to successful completion of a task, e.g. “Your group needs to share out the tasks if you want to finish on time”, or to focus attention, e.g. “I need you to join me here so I can explain that.”
Organisational interactions impact indirectly on student achievement in a number of ways. For example, one study found that students in classrooms rich in positive organisational interactions showed higher behavioural engagement, which in turn positively predicted literacy achievement (Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009). The effective teachers in Maori immersion settings studied by Bishop, Berryman and Richardson (2002) were noted for their excellent skills in classroom management and their non-confrontational style of managing behaviour. These qualities were described as contributing to the academic success of their students. There is some evidence of more direct effects of organisational interactions. A study by Cadima, Leal and Burchinal (2009) found that quality of TSI, particularly in terms of classroom organisation, was positively associated with students’ literacy outcomes. Organisational interactions may also directly influence student behaviour. Luckner and Pianta (2011) found that children in fifth grade classrooms with higher quality organisational interactions had more positive observed interactions with their peers and lower teacher ratings of aggression and relational aggression.

Other literature suggests aspects of organisational interactions that somewhat negate the possible benefits attributed to them. Several authors suggest that classroom organisational interactions are limited in their value because their underlying function is largely as a tool for reinforcing traditional roles of student and teacher. Teachers are described as using them to maintain power or exert control (Pollard 1985; Alexander 1995). Bloome, Puro and Theodorou (1989), viewing organisational interactions from the perspective of cultural anthropology, suggest that they function as a procedural display, that is a display by teacher and students to each other of a set of interactional procedures which themselves count as ‘doing a lesson’, rather than a vehicle for learning.

It appears from the literature, that teachers with strong organisational skills, who use them to shape an orderly learning environment with clear expectations around learning and behaviour are likely to achieve positive student outcomes. However, although a connection between high quality organisational interactions and positive student outcomes probably exists, is not a direct one.

*Interactions that provide instructional supports*

As the term suggests, instructional supports are those interactions whereby teachers create opportunities for students to develop new ways of thinking, learn new skills and practice existing ones, by providing instruction and feedback (Hamre & Pianta, 2005; Hamre & Pianta, 2007; Luckner & Pianta, 2011). An instructional interaction might involve modelling a skill, e.g. “I’m going to use a capital letter, because it’s after the full stop and it’s the first word in my new sentence”, or asking a question e.g. “Can you find the clues the author used to tell how this character felt?”.

It has been claimed that effectiveness of instruction is the most important factor in student success.
Numerous studies have sought empirical evidence to support a positive correlation between quality instructional interactions and student achievement. In reviewing more than 200 such studies, Brophy and Good (1986) found that students achieved more in classes where teachers were actively teaching i.e. interacting with their students. They identified particular teacher instructional interactions that maximised student achievement such as presenting information and developing concepts with clarity, posing questions that engage students in higher levels of thinking, and provision of appropriate feedback. Similarly, Webb and Vulliamy (1996), having extensively reviewed literature on classroom interaction, conclude that "... the clear message coming through classroom research over the last 20 years (is) that the crucial factor in improving pupils' learning, whatever approaches are employed, is that all children should experience, as often as possible, sustained higher-order work-related interactions with the teacher" (p. 26). These authors seem to agree that instructional interactions need to be of high quality, with particular mention made of those that encourage higher-order thinking skills.

**Feedback as a powerful form of interaction**

One aspect of instructional TSI that has received considerable attention is feedback. High quality feedback is at the heart of the principles of formative assessment or assessment for learning (Wiliam, 2011b), which as discussed previously is a key part of the student-centred focus of MLP. For this reason it is a type of TSI examined more closely in this study. Black and Wiliam (1998) position feedback as fundamental to learning and teaching. The definition selected for this discussion is that put forward by Hattie and Timperley (2007). They define feedback as "...information provided by an agent (e.g. teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding" (p. 81).

**Impact of feedback on student outcomes**

There is support for the proposition that feedback can raise student achievement (Black & Wiliam, 1998; Kluger & De Nisi, 1996). Hattie and Timperley (2007) claim that feedback is one of the most powerful influences on learning and achievement. However, they caution that this impact can be positive or negative. Having examined 12 meta-analyses that gave specific information on feedback in classrooms they concluded that the considerable variability in effect sizes showed that some types of feedback were more influential than others. Similar conclusions are reached in Kluger and De Nisi's 1996 meta-analysis, where they challenged the generally shared assumption of the time, that feedback consistently increases performance. They discovered that while on average feedback interventions were found to increase performance, one third actually decreased performance. Therefore, it is necessary to seek further evidence about the types of feedback that contribute positively to valued student outcomes.
Types of feedback
Numerous authors have attempted to identify the types of feedback that are effective in creating positive outcomes for students, with most suggesting that feedback linked to a specific behaviour or task is more effective than feedback about the person (Black & William, 1998; Hattie & Timperley, 2007; Kluger & De Nisi, 1996; Sadler, 1998). Kluger & De Nisi (1996) propose that feedback interventions are most likely to increase performance when attention is focused on gaps between attainment and performance at the task level. Conversely, performance decreases as feedback is more directed to the self. Hattie and Timperley (2007), propose that feedback at the level of self is the least effective type of feedback. They see feedback at the level of the task, as well as that aimed at the process and self-regulation needed to complete the task, as powerful within particular contexts.

A typology of feedback
A framework that may be used to examine feedback interactions in a structured way, is the typology developed by Tunstall and Gipps (1996). It was created as part of a classroom study investigating types of feedback given and children’s understanding of them. The typology is noted for the significant attention it has received since its creation by researchers and policy-makers, as well as in theoretical literature in the assessment field (Dixon, 2005). For this reason, it was selected as suitable for examining feedback interactions within this study. Table 2 draws together the key elements of the typology.

Table 2

A typology of teacher feedback.

<table>
<thead>
<tr>
<th>Socialisation Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td><strong>Role</strong></td>
</tr>
<tr>
<td>Socialisation/management</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td><strong>A1</strong></td>
</tr>
<tr>
<td><strong>B1</strong></td>
</tr>
<tr>
<td><strong>C1</strong></td>
</tr>
<tr>
<td><strong>D1</strong></td>
</tr>
<tr>
<td><strong>Positive Feedback</strong></td>
</tr>
<tr>
<td><strong>Achievement Feedback</strong></td>
</tr>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>Rewarding</td>
</tr>
<tr>
<td>Approving</td>
</tr>
<tr>
<td>Specifying attainment</td>
</tr>
<tr>
<td>Constructing achievement</td>
</tr>
</tbody>
</table>

<p>| <strong>Type</strong> |
| <strong>A2</strong> |
| <strong>B2</strong> |
| <strong>C2</strong> |
| <strong>D2</strong> |
| <strong>Negative Feedback</strong> |
| <strong>Improvement Feedback</strong> |
| <strong>Category</strong> |
| Punishing |
| Disapproving |
| Specifying improvement |
| Constructing the way forward |</p>
<table>
<thead>
<tr>
<th>Role</th>
<th>Classroom/individual management</th>
<th>Performance orientation</th>
<th>Mastery orientation</th>
<th>Learning orientation</th>
</tr>
</thead>
</table>


In this typology, feedback is divided into two main types, feedback of socialisation and feedback of assessment. Feedback of socialisation refers to those feedback interactions whereby teachers define roles, reinforce expectations for work and behaviour, and endorse common values. Feedback of assessment refers to the methods by which teachers provide information about learning, progress towards goals, and achievement. Tunstall and Gipps further break down assessment feedback according to whether it is positive or negative, and whether evaluative or descriptive. Type A feedback is evaluative feedback at its most positive or negative, where teachers express their desire to extrinsically reward or punish students for their efforts or behaviour. Type B feedback, while also evaluative, is more a means of expressing approval or disapproval, and is often considered a reward or punishment in itself. Both types of evaluative feedback align with the less effective ‘feedback about self’ previously noted by other authors. However, the types of feedback within the descriptive section of the Tunstall and Gipps’ typology show strong links to task-based types of feedback previously discussed as more powerful. Type C feedback identifies specific features either of attainment or for improvement. Students receive clear information as to what aspects of their learning or behaviour display competence, or where mistakes lie that can be corrected. Type D feedback is similar, but qualitatively different in that it involves both teacher and child in constructing either the pathway to achievement or a way forward for improvement. Therefore, it appears that teachers’ ability to provide high-quality feedback would be indicated by a predominance of Type C and Type D feedback.

Additionally, in a student-centred environment, such as the MLE is proposed to be, one would particularly expect to see evidence of the co-constructed Type D feedback.

**Teacher-student interaction and feedback in mathematics**

This research focused on interactions between teachers and students in mathematics as it was an area of personal interest for the researcher, as well as one where the literature suggests interaction and feedback are particularly important. Walshaw and Anthony (2008) believe that it is through interaction that students make sense of the world of mathematics and develop a mathematical disposition. They state that in mathematics teaching “Facilitating respectful and patterned interactions in the classroom contributes to the enhancement of students’ aspirations, attitudes, and achievements” (p. 542). Cornelius-White (2007) found mathematics to be a curriculum area where there is an exceptionally strong relationship between person-centred teacher variables and student achievement ($r = 0.36$). Additionally, provision of feedback has proven particularly powerful in
assisting student learning in mathematics, with Baker, Gersten, and Lee, (2002) noting a large effect size \(d = 0.71\).

**Implications of the literature for this study**
The literature review reveals an international paucity of research into the benefits of MLEs and MLPs. Given the rapid implementation of MLEs currently occurring in the New Zealand context, the need for research is urgent. Prior studies examining links between student learning spaces and student learning outcomes have largely focused on the tangibles, such as light, acoustics and furniture (Bissett, 2014). This study considers a less tangible aspect, but one that is at the very heart of teaching and learning: TSI. High-quality TSI can be considered a valuable outcome in itself, as well as being a predictor of other valued learning outcomes such as higher student achievement (Blackmore et al., 2011; Hattie, 2009). Therefore, assessing the impact of a MLE on TSI provides one criterion against which the success of the MLE may be evaluated. Formative assessment was identified as playing a key role in learning, and being a central component of student-centred MLP. For this reason, comparative analysis of feedback interactions provides some insight into the ways in which formative assessment practices are employed in a MLE. The study chose to focus on mathematics as a curriculum area where student success seems to be particularly sensitive to the effects of TSI and feedback. Other research on transition from traditional classrooms to a MLE has largely examined the effects on teachers (Blackmore et al., 2011). This study sought to expand this focus by allowing the voices of students in the transition to be heard alongside those of their teachers.
Chapter 3: Methodology

This chapter describes the research setting, participants, and the overall research design. The measures and procedures for collecting data are outlined, as well as the methods by which that data was analysed. An overview of the questions that guided the research is represented in Figure 5. The main research question, pictured in the yellow box, was: “What is the impact of a change from a single-space single-teacher learning environment to a multi-teacher multi-space modern learning environment on teacher-student interactions in mathematics?” This question was explored in two parts, directed by two sets of sub-questions. Firstly, it was necessary to build up a picture of the teacher-student interaction patterns that existed in each context to determine if any changes could be identified. This was achieved by answering the two questions pictured in the green boxes: “Is there a change in the duration and frequency of teacher-student interactions?”, and “Is there a change in the type of teacher-student interactions?” Secondly, in order to consider what the impact of the change in context might be from the perspective of the participants in those contexts, two further questions were posed: “Do teachers and students perceive any change in teacher-student interactions?” and “Do teachers and students identify a change in the factors that act as barriers and enablers to teacher-student interactions?”. These questions are shown in the blue boxes. The literature review highlighted feedback as an important sub-domain of instructional interaction, therefore it was decided to further include a focus on feedback within each sub-question.

Figure 5. Overview of main research question and sub-questions
Research setting

The study took place in an urban primary (Year 1-6) school within a large New Zealand city. In New Zealand, schools are assigned a decile rating by the MOE. The decile rating is described as “a measure of the socio-economic position of a school’s student community relative to other schools throughout the country” (Ministry of Education, 2015h, About deciles section, ¶ 1). It is calculated using data from the 5-yearly Census of Population and Dwellings (Ministry of Education, 2015h). The school in this study was a decile 10 school, meaning that it fell in the 10% of schools with the lowest proportion of students from low-socioeconomic backgrounds. The school was selected for the study via purposive sampling i.e. selected because it suited the purpose of providing an exemplar of the case being studied (Mutch, 2013). At the beginning of the study the school was nearing the completion of a major rebuild. Around half the school’s former traditional ‘single-cell’ classrooms were in the process of being replaced. The design of the new learning spaces encompassed the typical features of MLEs.

Participants

The participants included three Year 4 teachers and a sample group of 12 students from their classes. The Year 4 level was chosen as this was the level that the researcher had extensive experience, particularly in the area of mathematics. The teachers represented a range of age, gender and teaching experience. The flow of the teacher participants through the research may be seen in Figure 12, which can be found in the Research Design section of this chapter. The student participants were volunteers from the Year 4 cohort of 68 students. The flow of the student participants through the research is represented in Figure 13, included in the Research Design section of this chapter. Consent forms were sent to all Year 4 students and their parents. The initial proposal for the study suggested that a student participant group of up to 12 students be selected from the student volunteers by stratified random sampling. A stratified random sample is where subjects are selected at random from categories that represent the profile of the group being studied (Mutch, 2013). Three pre-established sampling criteria were set down:

1. Sample to exclude students with low achievement levels and those with high learning or behavioural needs

A number of authors (Babad, 1990,1992; Blatchford, Bassett & Brown, 2011; Brophy 1983; Lavy, Paserman and Schlosser 2012; Weinstein 1985,1989) identify that low achievers receive more teacher attention than high achievers. There was a concern that some students may have required a substantially higher level of teacher interaction to support their learning or behaviour, and therefore data gathered from them might not have been representative of the normal patterns of teacher-student interaction in the classroom. For this reason, students who would have been considered ‘well
below’ against the National Standard in mathematics, i.e. below Level 2 of the New Zealand Curriculum, the previous year were excluded from the sample group. In addition, teachers were asked to provide names of any students in the Year 4 cohort that they identified as having high learning or behavioural needs. The pilot of the student questionnaire, as described in the ‘Measures’ section, suggested that students with a limited knowledge of English should also be considered to have high learning needs.

2. Sample to represent a range of achievement levels

Babad (1993), in a review of research and theory pertaining to differential treatment of different students in the classroom, reports numerous studies that identify differential treatment of students according to teacher expectation of them being ‘high-achieving’ or ‘low-achieving’. He describes how these teacher expectancies are mediated through teacher-student interaction. Therefore it was assumed that selecting a sample group that represents students from a range of achievement levels may moderate teacher-expectancy effects on teacher-student interaction.

3. Sample to be gender balanced

There is considerable research evidence to support the proposition that boys and girls receive differential treatment in classroom interaction (Bailey, 1993; Duffy, Warren & Walsh 2001; Holden 1993; Hopf & Hatzichristou, 1999). A study of teacher-student interaction in science classrooms by Jones and Wheatley (1990) claims that boys receive a greater amount of every type of classroom interaction. Therefore, it was considered desirable that the sample group be, as far as possible, gender balanced.

There were 12 students who volunteered to participate for whom parental agreement to their participation was received. Data about these students were obtained from the school database and checked against the sampling criteria.

1. Students who were considered ‘well below’ against the National Standard in mathematics, i.e. below Level 2 of the New Zealand Curriculum, at the end of the previous year were to be excluded from the sample group. However, Figure 6 shows that there were no students within the student volunteer group that met this criteria for exclusion. No students in the Year 4 cohort were identified by the teachers as having high learning or behavioural needs, so none of the volunteer group was excluded on this basis.

2. Student achievement data was used to examine whether a range of achievement levels was represented in the student volunteer group. The students’ level of achievement in mathematics was represented by three sets of assessment data. The first data set was the students’ curriculum level (as assessed at the end of 2014 by their previous teacher) on entry to Year 4. The participant school
required teachers to assess each student’s achievement against the New Zealand Curriculum (NZC) levels, but in addition used the conventions of the e-asTTle assessment tool to denote sub-levels within each level. The e-asTTle tool was an online assessment developed by the MOE. It was designed to measure students’ achievement and progress (Te Kete Ipurangi, 2015a). Therefore a student’s level was represented by a number for their NZC level (from 1-8) and a letter to denote whether they might be considered at a basic (B), proficient (P) or advanced (A) stage for that level using the e-asTTle definitions. The second set of data was the students’ numeracy stage as assessed by the administration of the Global Strategy Stage (GloSS) assessment at the end of 2014 by their previous teacher. The GloSS assessment was a tool developed as part of the Numeracy Development Projects (NDP). The NDP was a set of professional learning and development initiatives in New Zealand schools between 2000 and 2009. The GloSS assessment was designed to determine the strategy stage a student was operating at as defined by the Number Framework, which forms an integral part of the NDP (Te Kete Ipurangi, 2015b). The third set of data was the students’ Mathematics Progressive Achievement Test (PAT) data for 2015 (scale scores and stanines). The Mathematics PAT was an assessment tool developed by the New Zealand Council for Educational Research (New Zealand Council for Educational Research, 2015).

When the 12 volunteer students’ data were mapped against that of the total Year 4 cohort to it was evident that students from a range of achievement levels were represented within the volunteer group. The volunteer group’s overall achievement level was of a similar range to that of the Year 4 cohort as a whole, with the exception that none of the volunteer group were represented in the lowest achievement levels. Figure 6 shows that the range of curriculum levels of the volunteer group on entry to Year 4 was similar to that of the whole Year 4 cohort, (whilst slight differences were evident with the low and high ability children, which will be noted in the discussion section).

![Comparison of volunteer group’s curriculum level on entry to Year 4 with that of Year 4 cohort group.](image-url)

*Figure 6. Comparison of volunteer group’s curriculum level on entry to Year 4 with that of Year 4 cohort group.*
Figure 7 shows that the range of GloSS stages of the volunteer group on entry to Year 4 was similar to that of the whole Year 4 cohort. Again disparities between the groups were evident in the two extremes (high and low achieving children).

Figure 7. Comparison of volunteer group’s GloSS stage on entry to Year 4 with that of Year 4 cohort group.

Figure 8 shows the volunteer group’s Mathematics PAT scale scores against those of the Year 4 cohort. The volunteer group’s scores fell within the middle to upper part of the range of scores for the Year 4 cohort.

Figure 8. Comparison of volunteer group’s Mathematics PAT scale scores compared to Year 4 cohort group.
Figure 9 shows the volunteer group’s Mathematics PAT stanine scores against those of the Year 4 cohort. The volunteer group’s scores fell within the middle to upper part of the range of stanine scores for the Year 4 cohort.

Figure 9. Comparison of volunteer group’s Mathematics PAT stanine scores with that of Year 4 cohort group.

3. As six girls and six boys volunteered to participate, the criteria of gender balance was met.

Having met the three sampling criteria, the student volunteer group was confirmed as a suitable sample group. The teachers had decided that the Year 4 students should be grouped according to ability for mathematics based on the GloSS test results. This meant that each teacher would take a mathematics class with a group of students of similar ability. The classes were reviewed and changes made if thought necessary at the beginning of each term. The highest group was taught by Teacher 2, the mid-range ability group by Teacher 1, and the lowest group by Teacher 3. The sample group consisted of three students from the highest group, three from the middle group and six from the lowest group. Therefore it should be noted that each class was not equally represented within the sample group.

The sample group consisted of 12 Year 4 students: six boys and six girls, ranging in age from 8 to 9 years.
Ethical considerations

Participation in the research was voluntary for all parties. All information supplied was treated as confidential. The research assistants signed confidentiality agreements. The reporting of the results was done in such a way as to protect the participants’ anonymity. No names or other information that might lead to identification of the participant school, teachers or students was included. As the participants would know of each other’s involvement in the research, quotes from participants were recorded in such a way that they could not be attributed to any particular teacher or student.

Research design

In designing the research, the researcher acknowledges that her own assumptions as to how knowledge about the central question might be best attained reflect a social constructivist perspective as described by Creswell (2003). The focus is on a specific social context: a learning environment. It seeks to understand the world in which a group of teachers and students work. It allows for individuals to develop multiple, subjective and socially negotiated meanings of their experiences of this environment. It explores the process of interactions among individuals. Rather than starting with a theory, the design allows for a theory or pattern of meaning to be developed inductively from the research. An inductive process will derive theoretical ideas from the data, not present hypotheses in advance of the data collection (Bryman, 2012).

The decisions made about methodology are influenced by Neuman’s (2011) three main approaches. These are summarised in Table 3 alongside methodologies suggested as typical of each approach (Mutch, 2013)

Table 3

<table>
<thead>
<tr>
<th>Approach</th>
<th>Definition</th>
<th>Typical Methodologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positivist</td>
<td>“an organised method for combining deductive logic with precise empirical observations of individual behaviour in order to discover and confirm a set of probabilistic causal laws that can be used to predict general patterns of human activity” (Neuman 2011, p. 95)</td>
<td>Surveys Experiments</td>
</tr>
</tbody>
</table>
Interpretivist

“the systematic analysis of socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at understandings and interpretations of how people create and maintain their social worlds”
(Neuman 2011, p. 101)

Case studies
Ethnographies

Critical

“a critical process of inquiry that goes beyond the surface illusions to uncover the real structures in the material world in order to help people change conditions and build a better world for themselves”
(Neuman 2011, p. 108)

Can be borrowed from other approaches e.g. case study, survey


The researcher took an interpretivist approach to addressing the central research question. It was decided that the impact of the change from a traditional single-cell, single-teacher learning environment to a multi-teacher, multi-class MLE should be explored by direct access to a setting where this change was taking place. This allowed a comparison of the same participants in the natural setting of two different learning environments.

Mutch (2013) links the interpretivist perspective with case study and ethnographic methodologies. However, as the research was conducted by a teacher practitioner and investigated teaching practice, the researcher turned to the area of practitioner research in educational settings to guide the research design. The purpose of the research was to describe the impact of a change of teaching practices in mathematics through the lens of teacher-student interactions in a specific context - that of the MLE. This purpose aligns closely with the central purpose of problem-based methodology (PBM) which is described as “to explain, evaluate, and improve teaching practices in ways that are rigorous as well as relevant to the particular context in which a teacher is working” (Robinson & Lai, 2005, p.15). Therefore, the PBM framework was chosen for the research design. In this study, the problem explored was the move from a single-cell environment to a shared space MLE. Robinson and Lai see teaching practices as the means by which teachers solve such practical problems. They believe that the practices reflect a particular theory of action that has been formulated in response to the problem. Such a theory may be an ‘espoused theory’ that is derived from the teachers’ descriptions of how they act. Alternatively it may be a ‘theory-in-use’ that can be seen by direct observation. Robinson and Lai propose three questions that act as prompts for the three main decisions required when using PBM in
research design. These decisions are driven by the research question. The process by which the main research question was used to make these decisions is depicted in Table 4, along with the implications for the research design.

Table 4

*Decisions made and implications for research design stemming from the choice of PBM to investigate the main research question.*

<table>
<thead>
<tr>
<th>Main Research Question:</th>
<th>Investigate current practice at two points in time in two different learning environments.</th>
<th>Requires: a definition of teacher-student interaction</th>
<th>a description of teacher-student interaction across two learning environments from perspectives of: - teachers - students - researcher as outside observer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your question require you to investigate past, current or future practice?</td>
<td>Describe the actions. Identify the constraints on these actions. Investigate consequences (both intended and unintended) of the change in learning environment on teacher-student interaction.</td>
<td>Investigate the relationship between constraints and actions</td>
<td>describe the consequences and identify the actions that explain those consequences</td>
</tr>
<tr>
<td>Which components of a theory of action does your research require you to investigate?</td>
<td>Does your research question require you to both describe and evaluate theories of action?</td>
<td>Investigate the consequences of the change, no evaluative component.</td>
<td></td>
</tr>
</tbody>
</table>

The implications for the research design that emerged from this process guided the development of four sub-questions investigated in the study as outlined in Figure 5.

When selecting methods for collecting information, Robinson and Lai believe that three aspects of the research question should influence the decision. The first is whether the research question is of the “exploratory” or “checking” variety. Exploratory questions are described as being more open-ended and attempt to discover what is happening, why, and with what consequences. Whereas, checking questions ask whether a particular thing is happening. It was decided that the research questions in this study fall into the category of exploratory questions. Therefore methods that provide the ability to explore unexpected lines of inquiry, such as semi-structured interviews, were chosen. The second consideration is which type of the theory of action is being addressed in the questions. It may be that they investigate theories-in-use where, usually by firsthand observation, we describe and explain how people act. Alternatively, they may explore espoused theories which are based on people’s reports of what they do and the reasons why. It was decided that the sub questions in this study require investigation of both theories-in-use and espoused theories. Therefore methods that allowed for firsthand information, such as observation and fieldwork were chosen to provide information on theories-in-use. These were combined with methods that ask people about what they think is happening, such as questionnaire and interview, to provide information on espoused theories. The final aspect that Robinson and Lai see as important in determining the type of information required is the clarification of key terms within the question. In this case the term teacher-student interaction was more specifically defined as verbal interaction from teacher to student. The methods by which information was gathered were required to capture information about verbal interaction from teachers to their students. During the creation of the measures for the study this clarification of key terms, guided by the literature review, was used to create a more detailed definition of teacher-student interaction.

An overview of the research design process is presented in Figure 10.
This type of research, where people are being studied in their natural environment, tends to focus on qualitative methods (Bryman, 2012). However, in this case a mixed methods approach was identified as being most suitable for a number of reasons. Firstly, the design process identified a need to explore all three components of a theory of action (actions, constraints and consequences) and both types of theory of action (theory-in-use and espoused theory). Investigation of this range of aspects suggested that a range of methods may be required to gather information. In particular it was decided that quantitative methods would provide more useful data about theory-in-use and should therefore be included. Secondly, appropriate methods that emerged from the design process were observations, fieldwork, interviews and questionnaires. These methods indicated both quantitative and qualitative approaches may be required in data gathering and analysis. Thirdly, a mixed methods approach is
supported by similar studies of teacher-student interaction that tend to use a combination of quantitative and qualitative methods (Alexander, 1995; Cadima, Leal & Burchinal, 2010; Smith, Hardman, Wall & Mroz, 2004; Webb & Vuillamy, 1996). Finally, the research design literature suggests a mixed methods approach is suitable for this type of research problem. Creswell and Plano Clark (2011) believe that the nature of the research problem may indicate a need for a mixed methods approach. They propose that a need may exist because one data source may be insufficient, to explain initial results, to generalise exploratory findings, to enhance a study with a second method, to best employ a theoretical stance, and to understand a research objective through multiple research phases. Two of these needs exist in the research problem for this study. The first is that one data source is unlikely to be sufficient to answer the research questions. There are several reasons for this assertion. There may be a mismatch between what people report doing or thinking and what they actually do or think (Robinson & Lai, 2005). This raises the possibility of different data types being contradictory. However, this would not be discovered if only one type was collected. Therefore quantitative data from observations would be a valuable addition to that gathered through interviews. It appears unlikely that one type of evidence would be able to capture the nuances of the interpersonal interactions being studied, particularly if that evidence was only quantitative. Creswell and Plano Clark (2011) also suggest that different data collection methods may be required for exploring different levels of the organisation. In a school setting the methods for collecting data from students may need to be different to that used with teachers. The second need in this study is for methods that allow deeper exploration of the initial results of the study. While quantitative data may provide a clear description of teacher actions in both learning environments, the constraints on actions and the consequences of actions need other methods to reveal deeper understanding of the actions.

Therefore having determined that a mixed-methods approach would be most appropriate it was decided to use the procedures sequentially. Quantitative methods were used first to gather descriptive data, as well as highlight areas of interest to be further examined. This was followed by qualitative methods to expand on the quantitative data and explore individual perspectives. There is some evidence that the use of quantitative methods followed by qualitative methods produces inconsistent data sets. Harris and Brown (2010) review 19 questionnaire-interview studies and find weak consistency and consensus between these methods. They recommend that these statistics might be improved by researchers ensuring that they maintain a tight focus on the construct being examined. They believe close alignment of the measures developed for each method is very important. Additionally they suggest that both types of data be collected with minimal time gap. The means by which the researcher took these points into consideration are detailed in the description of the measures developed and procedures employed later in this chapter. Mixed methods approaches are characterised by the inclusion of both open- and closed-ended questions, the use of both emerging and predetermined approaches, and both quantitative and qualitative data and analyses (Creswell, 2003). These characteristics are evident in the methods selected by the researcher, the type of data
gathered, and the subsequent data analysis conducted. The in-class teacher observations gathered information about the frequency, duration and types of interactions that the teachers had with their students through the use of time-sampling, running records and field notes. The questionnaire provided information about how the students viewed the interpersonal behaviour of their teacher/s. The face-to-face interviews provided further qualitative data from the perspective of the students, as well as a teacher perspective on their interactions. Figure 11 shows the links between the research questions, the methods selected and type of data gathered using each method, and the timeline for data gathering.

![Figure 11. Research questions and their associated data gathering methods](image)

Data about teacher-student interactions in a traditional classroom was gathered from the participant group of teachers and students. This was used as a baseline for comparison with data gathered from the same group after moving to the MLE in the later part of the year. This aspect aligns with the description of a single-subject or single-case design provided by Mutch (2013). The study reflects a repeated measures design as the same measures were used to gather both sets of data. The
opportunity to implement a repeated measures design is a strength of this research as it allows the impact of the changed learning environment on the participants to be explored directly. However, the time elapsed between the administration of measures is also a potential weakness of the design. It opens up the possibility of a maturation effect. Neuman (2011) lists this as one of 12 possible threats to the internal validity of research design. He defines a maturation effect as being when natural processes that occur during the time over which an experiment is conducted affect a dependent variable. In this study any changes noted between the two contexts might be attributable to maturation of the students themselves, of the relationship between the teachers and students, and of the relationship between the teachers. Ensuring that the time between repetition of the measures was minimised as far as possible mitigated this potential weakness. This allows greater validity to be attributed to possible claims that any changes are the result of the changed environment, rather than changes that would have occurred anyway as a result of the passing of time. However, the decision to minimise the time between measures had to be balanced with the need to overcome another possible limitation. There was a concern that the validity of the data for the second set of measures might be adversely affected should the measures be repeated too soon. It was felt that the participants needed sufficient time to re-establish themselves physically in the new context, as well as establish routines and expectations for the new social structure of the MLE. Therefore the interval chosen between the first and second set of measures was carefully evaluated against these two competing requirements. It was decided that the measures would be repeated after the participants had spent seven weeks in the MLE. The data gathering process occurred twice during the research period: in June prior to the participants moving to the MLE, and in September after the participants had been in the MLE for seven weeks. i.e., students completed the same questionnaire on both occasions, and were interviewed twice (once while in their normal/traditional classrooms and once when in the MLE); the teacher participants were observed and interviewed on two occasions, once in June while they were in their normal/traditional classrooms and again in September after they had spent seven weeks in the MLE.

Figure 12 shows the participant flow of the teachers throughout the research study.
Figure 12. Outline of participant (teachers) flow throughout the research study.

Figure 13 shows the participant flow of the students throughout the research study.
Diagram demonstrating participant flow (of students) over the duration of the research.

Figure 13. Outline of participant (students) flow throughout the research study
Measures

This section outlines the development and piloting of the measures.

Teacher observations

The key purpose of the observations was to gain information as to the theory-in-use component of the teachers’ theories of action. Robinson and Lai (2005) recommend gathering such factual information by observation. They cite research evidence that suggests that people’s reports of what they think or believe to be the case are generally inaccurate. Therefore, data regarding teacher-student interactions were gathered using a researcher-designed observation schedule alongside a running record of teacher-student interactions.

Using the teacher observation schedule (Appendix C) observations were recorded for each teacher over a 30-minute period within a one-hour maths lesson using ‘time-sampling’. This is a sampling method where a criterion is set for when observation will occur (Bryman, 2012). In this case the criterion was a one-minute interval. At one-minute intervals the main audience for the teacher-student interaction occurring was recorded according to predetermined codes. These codes were developed to match groupings one might normally expect to see in the context of a mathematics lesson (as determined by the researcher, an experienced teacher of mathematics at this level). Coding indicated the size of the student group that the teacher was observed interacting with in each one-minute period, the purpose being to record the frequency of teacher interactions in terms of the type of audience interacted with.

Audience Codes

N  No verbal interaction with student/s
I  Individual verbal interaction with one student
S  Small group verbal interaction with a group of between 2 and 8 students
L  Large group verbal interaction with a group of between 9 and 20 students
W  Whole class verbal interaction with a group of 21 or more students
R  Roving with interactions mixed between individuals and/or small groups

This aspect of teacher-student interaction was explored in response to literature previously discussed that suggests students’ mathematical self-concepts and skills develop most fully where they have opportunities to work both individually and collectively (Anthony & Walshaw, 2009).

During the observation a running record of all teacher-student verbal interactions was made for a 30-minute period within a one-hour maths lesson. The purpose of this was to gather information about:
- the frequency of particular types of teacher-student interaction according to the function of each interaction as defined by Hamre and Pianta (2007)
- the frequency of particular types of feedback according to the typology developed by Tunstall and Gipps (1996)
- the duration of teacher-student interactions

Additional field notes were made where the recorder considered these pertinent. Field notes are defined by Mutch (2011) as formal and informal notes that a researcher may make before, during, and after work ‘in the field’. She provides an example of three different types of field notes - descriptive, reflective and analytic - and discusses the value of each to the researcher. She describes the usefulness of descriptive field notes for setting the scene. In this study, the context is an important aspect and therefore it was decided that descriptive field notes would enhance the data gathered during the observation by providing a rich description of its setting. Reflective field notes record the researcher’s response to what is seen. Mutch believes such field notes are especially important in capturing nuances that cannot be captured in a transcript. Therefore it was considered important to include reflective field notes alongside the observation running record, as the transcript alone may not be sufficient. Analytic field notes are the means by which emerging patterns and themes may be noted by the researcher. As the study was inductive in nature, the recording of analytic field notes would possibly provide data to support emerging findings during the research process.

The teacher observation process was piloted in a Year 4 class at another school. It was a straightforward procedure to complete the observation schedule coding. The recording process was manageable in the classroom setting. Therefore no revisions were made as a result of the pilot. However, it was noted that an additional recorder would be valuable in a multi-teacher setting. This would allow the observation schedule to be used for more than one teacher simultaneously and so build up a picture of the interactions with different student groupings where there were multiple teachers. This would allow comparison with observations in the single teacher setting.

**Teacher interviews**

Semi-structured individual interviews of 15-20 minutes duration were conducted with teachers on two occasions during the study. Interviews were included in the measures as a means for investigating teachers’ espoused theories. Whereas structured interviews follow a set format with predetermined questions, a semi-structured interview tends to be more open-ended, although a set of key questions are used as the basis for the interview (Mutch, 2013). The semi-structured interview format was chosen as the researcher required a method to obtain qualitative data in contrast to the quantitative data from the observation schedule. Mutch suggests that the semi-structured format is more suited to obtaining qualitative data as it provides an opportunity to gain a deeper understanding of the topic from the perspective of the participant. For the first interview the researcher developed a set of key
exploratory questions. The purpose of these questions was to gather data that could be used as a basis for comparison with that gathered in the second interview. The interview schedule was developed using a format adapted from Robinson and Lai (2005) as shown in Table 5.

Table 5

*Purpose and types of questions included in teacher interview schedule for Time 1.*

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Relevance to Theories of Action</th>
<th>Type of Question</th>
<th>Example Interview Questions Time 1 - Baseline Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test teacher conceptions of interaction as compared to the literature</td>
<td>actions constraints</td>
<td>exploratory</td>
<td><em>I’d like you to tell me a bit about the different ways that you interact with students in your maths class. What are the purposes of these interactions?</em></td>
</tr>
<tr>
<td>Test teacher conceptions of feedback as compared to the literature</td>
<td>actions constraints</td>
<td>exploratory</td>
<td><em>What methods do you use to give feedback to students in maths? For example - How do you let students know when they have been successful?</em></td>
</tr>
<tr>
<td>SQ1. Is there a change in the duration and frequency of teacher-student interactions or feedback?</td>
<td>actions</td>
<td>exploratory</td>
<td><em>Thinking about maths times over a typical week, roughly how often do you get to interact with each student individually? in a group setting?</em></td>
</tr>
<tr>
<td>SQ2. Is there a change in the type of teacher-student interactions or feedback?</td>
<td>actions</td>
<td>exploratory</td>
<td><em>Are there any kinds of interaction with your students that you would like to have more of? to have less of?</em></td>
</tr>
<tr>
<td>SQ3. Do teachers and students perceive any change in teacher-student interactions, feedback? (frequency, duration, type)</td>
<td>actions</td>
<td>exploratory</td>
<td><em>Which methods of feedback do you think you use most often? Why?</em></td>
</tr>
</tbody>
</table>
SQ4. Do teachers and students identify a change in the factors that act as barriers and enablers to teacher-student interactions or feedback?


The first interview was piloted with a Year 4 teacher at another school. A review of the interview transcript satisfied the researcher that the questions produced the desired information. Therefore no revisions were made as a result of the pilot. The first interview (indicative questions Appendix D) was conducted in June.

The second interview was conducted in September. At this time the teachers had worked in the MLE space for seven weeks. The main purpose was to collect data about changes identified by teachers in their interactions with students across the domains of instructional, organisational and emotional supports. In addition, the particular enablers, barriers and constraints on action identified by each teacher in the first interview were further explored. Teachers were asked to comment on how they saw the impact of the move to the MLE on these enablers, barriers and constraints as well as discuss new ones they identified. The interview provided an opportunity for teachers to share their espoused theories of action in relation to their interaction with students during the teaching of mathematics in the MLE. The same format as used for the first interview was used to develop the interview schedule as shown in Table 6.

Table 6

*Purpose and types of questions included in teacher interview schedule for Time 2.*

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Relevance to Theories of Action</th>
<th>Type of Question</th>
<th>Example Interview Questions Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ1. Is there a change in the duration and</td>
<td>actions</td>
<td>exploratory</td>
<td><em>So previously you said you generally saw your groups around three times per week. What impact has the new</em></td>
</tr>
<tr>
<td>frequency of teacher-actions constraints</td>
<td>constraints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>consequences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ2. Is there a change in the type of teacher-student interactions or feedback?</td>
<td>actions</td>
<td>constraints</td>
<td>consequences</td>
</tr>
<tr>
<td>SQ3. Do teachers and students perceive any change in teacher-student interactions or feedback? (frequency, duration, type)</td>
<td>actions</td>
<td>constraints</td>
<td>consequences</td>
</tr>
<tr>
<td>SQ4. Do teachers and students identify a change in the factors that act as barriers and enablers to teacher-student interactions or feedback?</td>
<td>actions</td>
<td>constraints</td>
<td>consequences</td>
</tr>
</tbody>
</table>


Indicative questions for the second interview are included in Appendix E.

**Student questionnaires**

The purpose of the student questionnaire (Appendix F) was to develop a picture of the frequency of teacher-student interaction and feedback reported by students in their current classroom context by considering:

- How often do they experience different types of teacher-student interactions?
- How often do they experience different types of feedback from their teacher?

The same questionnaire was completed on two occasions, once while students were in the traditional classroom setting and once after seven weeks in the MLE setting.
The questionnaire was designed to measure the students’ responses on a summated rating (or Likert) scale. The choice of the Likert scale was made firstly because it provides a simple means to quantify an opinion (Evans & Rooney, 2014). In this case it provided a straightforward method to total the responses for interaction and feedback in general, as well as particular types, and so gain a picture of students opinion about how frequently they experienced these in their maths class. The Likert scale is a widely used tool in social science research (Kumar, 2011; Neuman, 2011). In addition the use of Likert scales with primary-aged students is not uncommon in the New Zealand context, featuring in standardised assessment tools such as e-asTTle, as well as student surveys such as those in the Wellbeing@School and Inclusive Practices Tools (Wellbeing@School, 2015). Therefore it was felt that there was a strong likelihood of students having prior experience with completing this type of scale. The researcher felt that this would enhance the ease of administration and also minimise any lack of accuracy that might result from participants’ confusion as to how to complete the scale. The number of points for the scale was selected in light of research literature which suggests that a scale of between five and seven points is effective in most cases. Scales of fewer than three points are felt to provide too little information, while those of greater than ten points place too higher demands on the respondents (Robinson & Lai, 2005). As the participants were children the lowest number of points within the ideal range was chosen i.e. a five-point scale. An odd-numbered scale was considered desirable as it allowed for two absolutes/extremes/poles and a relatively neutral in centre. The bi-polar scale used a semantic differential approach, that is where respondents are given two adjectives or adverbs that are polar opposites and are asked to mark one of several spaces between the two (Neuman, 2011). In this case there was a mid-point between each pole and the neutral. The points on the scale were labelled according to the frequency of particular interactions occurring: ‘never’, ‘hardly ever’, ‘sometimes’, ‘lots’, and ‘always’.

The 17 structured items were developed from the two typologies that form the basis of the teacher observation schedule (Hamre & Pianta, 2007; Tunstall & Gipps, 1996) as follows:

- Two items for each of the overall interaction types
  - Interactions that provide emotional supports
  - Interactions that provide organisational supports
  - Interactions that provide instructional supports
- One item for the feedback of socialisation
- One item for each of the assessment feedback types A1, A2, B1, B2, C1, and C2
- Two items for each of the assessment feedback types D1 and D2 (as this is the type of feedback identified in the literature as being most effective e.g. high-quality)

The items were placed in order by randomly drawing from within the groups of feedback and interaction items. An additional open-ended response item was included at the end of the
questionnaire to allow the researcher to identify any possible other areas for discussion within the follow-up interview.

The researcher used her extensive experience in teaching students at this level to develop the questionnaire at an appropriate level. The students in the sample group had PAT Reading Vocabulary and Reading Comprehension stanine scores of between 6 and 9. Items were written taking into account the literacy levels of students in terms of vocabulary choices and the length and complexity of sentences. A simple response format required students to circle their choice. Labels for each point were in simple language that students of this age could understand. In addition, the administration provided for the questions to be read, to provide additional support for the students in understanding what they were being asked.

The student questionnaire was piloted with 67 students in three Year 4 classes at another school. From the pilot it was determined that:

- the length of questionnaire was appropriate for the age group as students did not appear fatigued during or at the end of the time
- it fitted into the estimated time slot allowing 5 minutes for organisation and 10 minutes to complete the questionnaire
- data collation was straightforward

The following changes to the format and content were made as a result:

- questionnaire to be provided single-sided.
- rather than indicate points on the scale with a number from 1 to 5 above each label, remove the number so as to avoid risk of participants thinking that a particular response is better than another based on the number allocated to it.
- adjust directions by adding in that each sentence will be read twice, and clarify the meaning of the word confidential
- four items were slightly reworded to make a less complex sentence construction
- two items were reclassified as better representing a different feedback type.

It was also noted that students who are relatively new English language learners should be identified as having high learning needs and be excluded from sample group, as the questionnaire was too difficult for students with a limited knowledge of English.

**Student interviews**

Semi-structured individual interviews of approximately 10 minutes duration were conducted with the student sample group on two occasions during the study. As with the teacher interviews, the semi-structured interview was selected to provide qualitative data that would complement the quantitative
data gathered by other methods, in this instance the student questionnaire. The purpose of the first interview (indicative questions Appendix G) was to obtain qualitative data on their interactions with their teachers, and identify factors that they perceived as being barriers and enablers to teacher-student interaction. It also allowed follow up on any points of interest highlighted in their responses to the student questionnaire. The student interview schedule was developed using the same process as that for the teacher interviews. An overview of this is presented in Table 7.

Table 7

*Purpose and types of questions included in student interview schedule for Time 1.*

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Relevance to Theories of Action</th>
<th>Type of Question</th>
<th>Example Interview Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ1. is there a change in the duration and frequency of teacher-student interactions or feedback?</td>
<td>actions</td>
<td>exploratory</td>
<td>Do you think you get to spend enough time talking with your teacher in maths? Why/why not?</td>
</tr>
<tr>
<td>SQ2. Is there a change in the type of teacher-student interactions or feedback?</td>
<td>actions</td>
<td>exploratory</td>
<td>What kinds of things does your teacher talk to you about that help you learn when you are working in a group?</td>
</tr>
<tr>
<td>SQ3. Do teachers and students perceive any change in teacher-student interactions or feedback? (frequency, duration, type)</td>
<td>actions</td>
<td>exploratory</td>
<td>How do you know what your goals are in maths?</td>
</tr>
<tr>
<td>SQ4. Do teachers and students identify a change in the factors that act as barriers and enablers to teacher-student interactions or feedback?</td>
<td>constraints</td>
<td>exploratory</td>
<td>Are there any things that make it hard for you to work with your teacher in maths classes?</td>
</tr>
</tbody>
</table>

The purpose of the second interview (indicative questions Appendix H) was to check if the students perceived any changes to teacher-student interaction after moving into the MLE setting, and identify any barriers and enablers to interaction with their teachers in mathematics in the MLE. Once again, there was an opportunity to pose follow-up questions from their responses to the student questionnaire. In addition, particular barriers and enablers to teacher-student interaction in mathematics that students identified in the first interview were revisited. Students were asked if they identified those barriers and enablers as occurring the same amount, more often, or less often in the MLE. An overview of the question development is presented in Table 8.

Table 8

**Purpose and types of questions included in student interview schedule for Time 2.**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Relevance to Theories of Action</th>
<th>Type of Question</th>
<th>Example Interview Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ1. Is there a change in the duration and frequency of teacher-student interactions or feedback?</td>
<td>actions constraints consequences exploratory</td>
<td>* So tell me about your maths times in this new space. Think about maths times over the last week - what are they like? For example, tell me a bit about the amount of time you get with a teacher ...</td>
<td></td>
</tr>
<tr>
<td>SQ2. Is there a change in the type of teacher-student interactions or feedback?</td>
<td>actions constraints consequences exploratory</td>
<td>* In this new space, how do your teachers let you know what you’re meant to be doing?</td>
<td></td>
</tr>
<tr>
<td>SQ3. Do teachers and students perceive any change in teacher-student interactions or feedback? (frequency, duration, type)</td>
<td>actions constraints consequences exploratory</td>
<td>* Tell me about the things that help you if you get stuck in maths ...</td>
<td></td>
</tr>
<tr>
<td>SQ4. Do teachers and students identify a change in the factors that act as barriers and enablers to teacher-student interactions</td>
<td>actions constraints consequences exploratory</td>
<td>* You said that it was hard sometimes because you needed help but your teacher wasn’t always able to stop and help you. In your new space is this the...</td>
<td></td>
</tr>
</tbody>
</table>
Procedures
This section describes the procedures followed to administer the measures and collect data. The approval to carry out the research was granted by the University of Auckland Human Participants Ethics Committee on the 26th April 2015. All measures were carried out in the same school.
Permission to carry out the research in the school was sought from the school's Board of Trustees and Principal. They were provided with the relevant Participant Information Sheet and Consent Form. Permission for the research to be conducted at the school was given on 17th June 2015.

The Principal of the school approached the Year 4 teachers to ask their permission for the researcher to attend one of their regular team meetings to present an outline of the research. The Participant Information Sheet was discussed with them, and then left with them along with consent forms. Consent forms were returned in a sealed envelope to a labelled box in the school office. All three Year 4 teachers consented to participating. The researcher arranged to meet the Year 4 students to briefly explain the research, answer questions and distribute Participant Information Sheets for the students and their parents. Parent Consent Forms and Student Assent Forms were also distributed. Parents were informed of the opportunity to meet with the researcher to discuss the research at an after school meeting time. However, no parents took up this opportunity. The consent/assent forms were returned in a sealed envelope to a labelled box in the school office. The researcher collated a list of students for whom both a signed Student Assent Form and a signed Parent Consent Form had been received. There were 12 students on this list and, subsequent to the checks outlined earlier in the ‘Participants’ section, they became the student participant group. The researcher informed the students that they had been selected to participate.

Teacher observations
Observations took place during normal one-hour maths lessons. For Time 1 in the single-cell classroom, each teacher was observed for one 30-minute period during one maths lesson. The observation schedule and field notes were completed by the researcher. In the more compact space of the single-cell classroom it was also possible for the researcher to complete the running record. This was done by stop-start digital recording that captured the teacher’s verbal interactions. The recording was later converted into a typed transcript by the researcher. One teacher’s voice was too quiet to be audible for much of the digital recording and so no transcript was made for this teacher. For Time 2 in the MLE the three teachers were observed during a one-hour period. Time constraints
imposed by events happening within the school required the observations to be compressed into this timeframe. The researcher completed an observation schedule and field notes for two 30-minute periods for each teacher. A research assistant with advanced typing skills completed the running records. A running record was made for two of the teachers, each for one 30-minute period. It was not possible within the time constraint to make a running record for the third teacher. However, as no running record was completed for one teacher in Time 1, this same teacher was selected to be the one for whom no running record was completed in Time 2.

**Teacher interviews**

Teachers were given release from their classes during normal class time to meet with the researcher. On both occasions the researcher conducted individual interviews for approximately twenty minutes in a private withdrawal space within the team area of the school. Due to timetabling constraints within the school, the first round of interviews occurred one week after the in-class observations. Prior to the first interview (but after the teacher observations) the teachers were provided a list of indicative questions. This was to allow them to give thought to their answers and so allow the researcher to gain a clearer understanding of their views on the constructs being explored (interaction in general and feedback in particular) and the current barriers and enablers they identified in their class setting. The interviews were digitally recorded and a typed transcript produced by the researcher. The teacher participants were provided with a copy of the transcript for their comments, additions or amendments. None were made as a result of this. The teachers all felt that the transcript was an accurate and complete record of the interview. The second round of interviews took place three days after the in-class observations. Prior to the second interview the teachers were given a general guideline as to what direction the interview would take, in that it would examine the changes that they identified from their single-cell classroom to the MLE space. The researcher digitally recorded the interviews. The research assistant was used to make a typed transcript from the recordings. This was done as her superior typing speed allowed for the data to be sooner available for analysis. The teacher participants were provided with a copy of the transcript for their comments, additions or amendments. Once again no alterations were made as teachers were satisfied with the accuracy of the transcript.

**Student questionnaires**

The selected students were invited to meet with the researcher in an available empty classroom space. To ensure consistency of administration, the questionnaire was administered to all students at the same time. Each questionnaire was numbered and this was recorded against a student list. It was decided to not have students write their name on the questionnaire to convey a greater impression of confidentiality and therefore encourage them to be more open with their answers. Both written and verbal assurances of confidentiality were given to minimise the likelihood of students answering in a way that made their teacher appear positive, and increase the social desirability of their answers. The questionnaire was administered by a neutral party (the researcher) in an effort to increase the
likelihood of getting honest answers. The instructions were read to the students and they were given the opportunity to ask any questions to clarify the procedure for the questionnaire. The questionnaire was read for the students, with each statement for the structured response items being read twice. The questionnaire administration took approximately ten minutes, including reading the directions. Students were given approximately five minutes at the end to respond to the final open-ended response item if they wished to record anything in this section.

*Student interviews*
On both occasions, individual student interviews took place on the same day as the administration of the student questionnaire. Following the questionnaire administration, individual students were invited to meet with the researcher. Interviews were conducted in a private withdrawal space within the team area of the school that was familiar to the students. Prior to the interviews, the researcher viewed each student's questionnaire responses, noting any of interest to be followed up in the interview in addition to the planned set of interview questions. Each interview took approximately ten minutes and was digitally recorded. They were converted to a typed transcript by the researcher for Time 1 and, due to time constraints, by a research assistant for Time 2.

*Data analysis*

*Teacher observation schedules*
For each observation made the amount of time attributed to each audience code was calculated as a percentage of the total observation time of 30 minutes. The data were crosschecked numerically to ensure that the entire observation time was coded. The total minutes spent in teacher-student interaction was calculated and converted to a percentage of the total observation time. The Time 1 data were aggregated for all three observations (one for each teacher) and an overall percentage of the time spent with each audience type calculated for the single-cell learning environment. Similarly the Time 2 data were aggregated for all six observations (two for each teacher) and an overall percentage of the time spent with each audience type calculated for the MLE. A research assistant independently checked all calculations. The data for Time 1 and Time 2 for each audience type (no verbal interaction with students, individual verbal interaction with one student, small group verbal interaction with 2-8 students, large group verbal interaction with 9-20 students, whole class verbal interaction with 21 or more students, or roving interactions with individuals and groups) was then graphed for ease of comparison.

*Teacher observation running records*
In the first observation of Teacher 1, eight brief interactions were unable to be heard and so were not recorded. Reference to the field notes suggests these were simple acknowledgements that the student’s work was complete/correct. However, for the purpose of analysis they were included and
coded as uncodable. During the first observation of Teacher 2, the teacher’s voice was frequently inaudible and this aspect of the observation was abandoned due to insufficient detail in the interactions recorded. Therefore no running record was taken for this teacher during the second round of observations, and no running record data for Teacher 2 was included in the analysis.

a. Defining separate teacher-student interactions
Each running record was converted to a typed written transcript. The first unit of analysis was a teacher-student interaction. The transcript was divided into separate interactions using the definition provided by Alexander (1995). He defines a teacher-student interaction as “a complete stanza of conversation between the teacher and an individual, group or whole class of children” (p.134). To allow for the problem of interruptions intruding on the conversation (as may occur frequently in the classroom), Alexander makes the ruling that if, after an interruption, the conversation continues where it left off, the continuation is counted as part of the original interaction. However, if the conversation after the interruption enters a new phase or embarks upon a new topic, that marks the beginning of a fresh interaction. He also considers that the interruption counts as an interaction or part of an interaction in its own right. In these observations only teacher to student interactions were recorded. The only interruptions were student to teacher interactions and so they were not recorded. Two independent parties, the researcher and a research assistant completed the process of dividing one transcript into separate interactions using Alexander’s definition. The research assistant was a postgraduate research student who was familiar with the nature of the research project and its design. Inter-rater reliability was calculated as the number of agreements between raters divided by the total possible score (Robinson & Lai, 2005). The inter-rater reliability was 91%. One coder then divided all the remaining transcripts into separate interactions.

b. Coding the function of teacher-student interactions
Each verbal interaction between teacher and students was initially coded by type using a researcher-designed framework for classifying interactions according to their function. This analysis framework, shown in Table 9, uses definitions from the CLASS framework (Pianta & Hamre, 2009).
Table 9

**Framework for classification of classroom teacher-student interactions by function**

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Includes</th>
<th>Excludes</th>
<th>Example</th>
<th>Non-Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactions that provide</td>
<td>Those interactions whereby teachers create opportunities for students to</td>
<td>Questions where students are asked to recall an idea previously presented</td>
<td>Questions to students who are not paying attention</td>
<td>So we’re looking at using a number line and why would we use a number line?</td>
<td>So what do you think the answer is K? (to child not paying attention)</td>
</tr>
<tr>
<td>Instructional Support</td>
<td>create opportunities for students to develop new ways of thinking, learn new skills and practice existing ones, by providing instruction and feedback.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactions that provide</td>
<td>The means by which teachers manage the time, attention and behaviour of their students and the resources needed to support learning</td>
<td>Statements/questions used to capture attention of a student</td>
<td>Genuine queries as to how a student is physically or emotionally</td>
<td>So are you alright? You’re a bit sleepy this morning (to child not paying attention)</td>
<td>So are you alright? You’re a bit sleepy this morning (to child who appears to be falling asleep)</td>
</tr>
<tr>
<td>Organisational Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactions that provide</td>
<td>The means by which teachers create a positive emotional climate within the classroom</td>
<td>Statements that support class values/expectations</td>
<td>Statements where the predominant purpose is to gain compliance</td>
<td>It’s great to see you moving so quietly to your desk, L. (when moving quietly has been promoted as a valued action).</td>
<td>I like the way G is sitting up so nicely (when trying to get others to do same).</td>
</tr>
<tr>
<td>Emotional Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each verbal interaction was coded according to what was considered its main function as follows:

- **E** Main function to provide emotional support
- **O** Main function to support classroom organisation
- **I** Main function to provide instructional support

The interactions from one transcript were independently coded using the analysis framework by two coders, the researcher and the same research assistant who acted as the coder for the first analysis. The inter-rater reliability was 85%. Inter-rater reliability was calculated by the formula in Robinson and Lai (2005) described previously. One coder then coded all remaining transcripts.

c. Coding feedback

Interactions coded as **I** (Instructional) were then further examined to establish if they included examples of feedback. The texts of instructional interactions between teacher and students were scanned for examples of feedback according to the typology developed by Tunstall and Gipps (1996). An extract was considered to be an example of feedback if its content could be considered an exemplar of the feedback types in the Tunstall and Gibbs typology as outlined in Table 10.

**Table 10**

*Framework for classification of classroom teacher-student feedback by type*

<table>
<thead>
<tr>
<th>Category</th>
<th>Role/Characteristics</th>
<th>Includes</th>
<th>Excludes</th>
<th>Example</th>
<th>Non-Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Socialisation feedback</strong></td>
<td>Socialisation/management Relates to values, attitudes and classroom procedures</td>
<td>The need to make an effort, kindness, sharing, fairness. The need to follow certain procedures.</td>
<td>Rewards and punishments for displaying these values and attitudes or following procedures.</td>
<td>It makes our class a happy place when everyone shares the equipment.</td>
<td>X, you are going to lose a point for not sharing the equipment with Y.</td>
</tr>
<tr>
<td><strong>Assessment feedback</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Evaluative Positive feedback - rewarding</td>
<td>Classroom/individual management Used by teachers to express their desire to reward for effort/behaviour. Extrinsic motivation.</td>
<td>Person based feedback, both individual and group. Students effort, behaviour, personal attributes are the focus.</td>
<td>Approval linked to task without any form of reward or public praise.</td>
<td>You can have a sticker for trying so hard with that. X is such a clever girl isn't she?</td>
<td>You tried so hard to show your thinking about the problem.</td>
</tr>
<tr>
<td>A2 Evaluative Negative feedback - punishing</td>
<td>Classroom/individual management Used by teachers to express their complete disapproval Extrinsic motivation.</td>
<td>Criticism/disapproval linked to task without any form of punishment or public reprimand.</td>
<td>You have not tried so you will stay in at play. X is going to have to miss playtime since he has messed around.</td>
<td>You don't think you have done your best work there, X.</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Orientation</td>
<td>Feedback Description</td>
<td>Evaluation</td>
<td>Disapproval</td>
<td>Notes</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>------------</td>
<td>----------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>B1 Evaluative Positive feedback - approving</strong></td>
<td>Performance orientation Of an overall evaluative kind. Warm expression of teacher approval of child's work or engagement.</td>
<td>Person based feedback, both individual and group, but has greater focus on effort, behaviour in relation to performance of a task.</td>
<td>Rewarding. Positive evaluation against set criteria</td>
<td>Punishing. Negative evaluation against set criteria</td>
<td>You tried so hard to show your thinking about the problem. You have shown the jumps to the tens perfectly.</td>
</tr>
<tr>
<td><strong>B2 Evaluative Negative feedback - disapproving</strong></td>
<td>Performance orientation Of an overall evaluative kind. Where child considered to be at fault e.g. lack of effort or concentration.</td>
<td>Feedback against particular criteria as to whether student has been successful or not. Focus on describing where the performance has met the criteria or not and some direction as to how this might be done.</td>
<td>Reward or general approval.</td>
<td>Punishment or general disapproval.</td>
<td>You try so hard to show your thinking about the problem. You have forgotten to jump to the ten first.</td>
</tr>
<tr>
<td><strong>C1 Descriptive Achievement feedback - specifying attainment</strong></td>
<td>Mastery orientation Identifying and labelling the successful components of attainment. Specific praise, affirming what children have carried out successfully.</td>
<td>Feedback against particular criteria as to whether student has been successful or not. Focus on describing where the performance has met the criteria or not and some direction as to how this might be done.</td>
<td>Reward or general approval.</td>
<td>Punishment or general disapproval.</td>
<td>You have shown the jumps to the tens perfectly. You have shown the jumps to the tens perfectly.</td>
</tr>
<tr>
<td><strong>C2 Descriptive Improvement feedback - specifying improvement</strong></td>
<td>Mastery orientation Specifying how something that is being learned can be corrected. Focused on where the mistakes lie. Correction of mistakes as an opportunity to learn</td>
<td>Feedback against particular criteria as to whether student has been successful or not. Focus on describing where the performance has met the criteria or not and some direction as to how this might be done.</td>
<td>Reward or general approval.</td>
<td>Punishment or general disapproval.</td>
<td>You have shown the jumps to the tens perfectly. You have shown the jumps to the tens perfectly.</td>
</tr>
<tr>
<td><strong>D1 Descriptive Achievement feedback - constructing achievement</strong></td>
<td>Learning orientation Control passed to child. Teacher as facilitator rather than judge. Conveys a sense of work in progress.</td>
<td>Teacher facilitates student's ability to describe own current achievement and future learning. Mutual identification of areas of achievement and future learning goals.</td>
<td>Reward or general approval. Teacher alone identifies the success. X solved the problem by jumping to the tidy number first. And then what did you do next X?</td>
<td>Punishment or general disapproval. Teacher alone identifies the area for improvement. X solved the problem by jumping to the tidy number first. And then jumping in tens.</td>
<td>X solved the problem by jumping to the tidy number first. And then jumping in tens. X solved the problem by jumping to the tidy number first. And then jumping in tens. Next time she could jump all those tens in one big jump.</td>
</tr>
<tr>
<td><strong>D2 Descriptive Improvement feedback - constructing the way forward</strong></td>
<td>Learning orientation Articulate future possibilities in learning. Child has greater responsibility. Teacher in partnership with child. Improvement identified mutually.</td>
<td>Teacher facilitates student's ability to describe own current achievement and future learning. Mutual identification of areas of achievement and future learning goals.</td>
<td>Reward or general approval. Teacher alone identifies the success. X solved the problem by jumping to the tidy number first. And then what did you do next X?</td>
<td>Punishment or general disapproval. Teacher alone identifies the area for improvement. X solved the problem by jumping to the tidy number first. And then jumping in tens.</td>
<td>X solved the problem by jumping to the tidy number first. And then jumping in tens. Next time she could jump all those tens in one big jump.</td>
</tr>
</tbody>
</table>


If the content of the extract was not able to classified under one of these types, then it was excluded. The interactions were independently coded against the typology by two coders, the researcher and a research assistant. The inter-rater reliability was 89%. Inter-rater reliability was calculated as the
number of agreements between raters divided by the total possible score (Robinson & Lai, 2005). One coder then coded the remaining transcripts.

d. Coding duration of interactions
The duration of each teacher-student interaction was calculated using a word count tool within the word processing program. The teacher-student interactions were grouped by duration into the following intervals:

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief</td>
<td>10 words or less</td>
</tr>
<tr>
<td>Short</td>
<td>11 to 50 words</td>
</tr>
<tr>
<td>Moderate</td>
<td>50 to 100 words</td>
</tr>
<tr>
<td>Extended</td>
<td>More than 100 words</td>
</tr>
</tbody>
</table>

The number of words for each duration interval was expressed as a percentage of the total number of words in the transcript. A research assistant checked the accuracy of the word count and calculations.

Teacher interviews
Time 1 interview data was analysed separately prior to the Time 2 data. Each set of interview transcript data was reviewed following the three-step coding process suggested by Neuman (2011). Neuman labels the first step of the process open coding, where a first pass is made through the data looking for themes. Open coding of the interview data identified some themes in response to specific questions designed to test teacher conceptions of two key terms: interaction and feedback. Other themes emerged from questions that prompted teachers to identify possible barriers and enablers to teacher-student interaction. Further themes developed from the unique personal perspectives of individual teachers. Some themes reflected areas of commonality between the three teachers, for example beliefs about grouping for learning. Others highlighted areas of distinctly diverse viewpoints, such as in the area of setting and reviewing goals with students. Initial codes were assigned to the data, with data under each code highlighted in a different colour. The data were then grouped according to the assigned codes using the process of constant comparison. Neuman recommends that the second pass through the data, labelled axial coding, should focus on the initial coded themes. Within some, sub-themes emerged. For each theme or sub-theme, the content was then reviewed to identify the espoused theories exemplified by the data. The constraints and consequences of the espoused theories were suggested. The final pass through the data, Neuman calls selective coding, as one looks selectively for cases that illustrate the major themes. At this stage of the coding particular teacher responses were identified as exemplars of the major themes.
Student questionnaires

One student was absent for the Time 2 data collection and so no data for this student was included in any of the analysis. Student responses for each of the 17 structured items where they gave a rating for the frequency of each particular type of interaction occurring in the class were converted to a 1 to 5 scale, as follows:

Never = 1    Hardly ever = 2    Sometimes = 3    Lots = 4    Always = 5

The assignment of numeric values to student ratings for each item was independently checked by a research assistant to ensure 100 percent accuracy of the data. The data were entered into a computer spreadsheet and data entry checked by a research assistant to ensure its accuracy.

For the purposes of analysis, the data were separated into items relating to interaction in general and items relating to feedback. Those relating to interaction in general were considered first. An overall interaction frequency score for Time 1 and Time 2 was calculated by adding all student ratings for all six items. A Time 1 and Time 2 frequency score for each of the six items on interaction was calculated by adding all student ratings for that item. Next, Time 1 and Time 2 scores for each type of interaction (emotional supports, organisational supports, and instructional supports) were calculated. As there were two items for each type of interaction, the scores for the two items were averaged. This aggregated data was graphed to show Time 1 and Time 2 data together.

The data for overall interaction frequency was then disaggregated and graphed in three ways:

1. By gender - in response to literature that supports the proposition that girls and boys receive differential treatment in terms of teacher-student interaction. The data was separated to compare scores for boys and girls

2. By maths level - in response to literature that supports the proposition that students perceived as high-achievers receive differential amounts of teacher-student interaction to those perceived as low-achievers. The students’ data on maths entry level to Year 4 (possible score of 1 to 9), maths GloSS stage on entry to Year 4 (possible score of 1 to 8) and Year 4 PAT stanine score (possible score of 1 to 9) were combined to produce a numeric value that represented their overall maths level. The maths entry levels for the students were provided as New Zealand Curriculum levels, but in addition used the conventions of the e-asTTle assessment tool to denote sub-levels within each level. As a result the maths entry level for each student was represented as a combination of numbers and letters. It was converted to a single number to allow all three scores for each student to be combined. Table 11 shows this conversion.
Table 11

Conversion of maths curriculum entry level to single numeric value.

<table>
<thead>
<tr>
<th>Level 1B (Basic)</th>
<th>Level 2B (Basic)</th>
<th>Level 3B (Basic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 1</td>
<td>= 4</td>
<td>= 7</td>
</tr>
<tr>
<td>Level 1P (Proficient)</td>
<td>Level 2P (Proficient)</td>
<td>Level 3P (Proficient)</td>
</tr>
<tr>
<td>= 2</td>
<td>= 5</td>
<td>= 8</td>
</tr>
<tr>
<td>Level 1A (Advanced)</td>
<td>Level 2A (Advanced)</td>
<td>Level 3A (Advanced)</td>
</tr>
<tr>
<td>= 3</td>
<td>= 6</td>
<td>= 9</td>
</tr>
</tbody>
</table>

The data were graphed to compare the interaction frequency scores to each student’s maths level score.

3. By maths class - in response to the fact that students had been in three separate classes prior to the move into the MLE. The data were graphed to show the interaction frequency scores for each student grouped according to their maths class.

Next the items relating to feedback were considered. A Time 1 and Time 2 frequency score for each of the 11 items on feedback was calculated by adding all student ratings for that item. Then Time 1 and Time 2 scores for each type of interaction (Type S, Type A, Type B, Type C and Type D) were calculated. Where there was more than one item for a type of interaction, the scores for the items relating to that type were averaged. This aggregated data was graphed to show Time 1 and Time 2 data together.

The data were disaggregated to obtain an overall feedback frequency score for Time 1 and Time 2 for each student. This was calculated by adding each student’s ratings for all 11 items. The individual student score was then graphed in the same way as that for interaction (by gender, maths level, and maths class) to allow comparison of feedback frequency according to individual student characteristics.

No analysis was made of student responses to the one open-ended item, as the purpose of this item was solely to inform the researcher of potential areas to be further explored within the student interview.
Student interviews
Time 1 interview data were analysed separately prior to Time 2 data. As with the teacher interviews, each set of interview transcript data was reviewed on three occasions moving from open coding, to axial coding and finally selective coding. Questions that prompted students to talk about teacher-student interaction, feedback and barriers and enablers provided the majority of themes in the open coding process. The data was then grouped according to the assigned codes. During axial coding, several sub-themes emerged. Causes and consequences of the viewpoints expressed by the students were proposed. Finally selective coding was used to draw together major themes and exemplars for each. The student interview data were also used to triangulate data from other sources.

Evaluative criteria

The study was evaluated using five criteria suggested by Miles and Huberman (1994).

1. Objectivity/confirmability

The location of the study outside the researcher’s own school allowed a relatively high degree of neutrality. However, the researcher acknowledges the likelihood of some inevitable bias resulting from being involved in a similar process of change within her own school, albeit at an earlier stage than the participant school. As a primary school teacher, some degree of bias may also stem from the researcher’s own beliefs about effective teaching, learning and assessment practices.

2. Reliability/dependability/auditability

Reliability of the measures was established through a process of piloting with teachers and students in another school with adjustments made where necessary. Data analysis used structured frameworks that had a strong base in theoretical literature linked to the study. Therefore others could reliably use the measures and frameworks developed by the researcher. The procedures for administering the measures assured a high degree of consistency between Time 1 and Time 2 data gathering. Administration procedures were clearly outlined which would allow the study to be reliably replicated in a similar setting. Research assistants performed external auditing of the data. Entry of data and calculations made from quantitative data were independently checked. Coding of teacher observation data was subject to a process of dual coding with a minimum inter-rater reliability of 85%.

3. Internal validity/credibility/authenticity

The process of member-checking was used with the teacher interview data to ensure teacher participants’ confidence in its accuracy. Triangulation of more than one data source gave greater validity to the findings of the study. Peer debriefing took place, with extensive discussion of the emerging findings by a group of university staff and postgraduate students. The findings were
presented to a highly respected group from within education and the wider community for their comment and questions, and were well-received.

4. External validity/transferability/fittingness

The conclusions of the study have relevance to the experiences of many teachers and students, who will be involved in a similar process of transition to the participants. However the generalisability of the findings needs to be considered with caution in light of the small scale of the study, and the narrow context within which it was conducted. Description of the participants provided in this chapter may assist others to evaluate the degree of transferability to their own particular context.

5. Utilization/application/action orientation

The study has particular value for the participant school and teachers in that it suggests areas of focus for teaching, arranging for learning, and assessment in the MLE setting that may not have been highlighted previously. The participant students and their peers will benefit from the school’s heightened awareness of the impacts of the transition on students, particularly those student groups for whom a greater impact was noted.

Conclusion

This chapter has summarised the key methods and methodology used in this study. It has justified why their selection was appropriate. The ways by which the validity of methods and data analysis was established are outlined.
Chapter 4: Results

This chapter begins by reporting a summary of the changes that occurred in the mathematics programme between the two occasions on which data were gathered - the first time when teachers and their classes were in traditional “single-cell” classroom environments, and the second after seven weeks in the MLE. Following that the main question as to the impact of the change on TSI in general and feedback interactions in particular is considered by examining data gathered to answer each of four sub-questions. When reporting individual teacher and student comments, the use of pseudonyms was avoided. It was determined that the use of pseudonyms would increase the likelihood of specific participants being identified.

Summary of changes to mathematics programme

At the beginning of the third term three single-teacher classes (each of approximately 23 students) merged into one MLE of 68 students with three teachers. After seven weeks in the MLE, the teachers had made extensive changes to their mathematics programme, particularly in the ways that students were arranged for learning and the contexts within which interaction took place. These are summarised in Table 12.

Table 12

Summary of participants' mathematics programme

<table>
<thead>
<tr>
<th>Aspect of Programme</th>
<th>Time 1: Single-cell environment</th>
<th>Time 2: MLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of mathematics</td>
<td>Number</td>
<td>Number</td>
</tr>
<tr>
<td>Domain</td>
<td>Multiplication and division</td>
<td>Ratios and proportions</td>
</tr>
<tr>
<td>Within team groupings</td>
<td>3 classes, grouped by ability according to GloSS stage, fixed for whole term</td>
<td>No set groupings</td>
</tr>
<tr>
<td>Within class groupings</td>
<td>3-4 groups, grouped by ability according to GloSS stage, relatively fixed for whole term, although some provision to move students between groups or combine groups.</td>
<td>Variable groupings according to responses to individual items on pre-test. Continually changing according to student evidence of mastery of learning from specific item.</td>
</tr>
<tr>
<td>Weekly Programme</td>
<td>Time</td>
<td>Daily 1-hour session Monday-Friday, 9.00am-10.00am: Same format every day as below</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Programme Format</td>
<td>'Warm up' - maths class 10 minutes</td>
<td>'Warm up' - home class 10 minutes</td>
</tr>
<tr>
<td></td>
<td>Group rotation created by teacher</td>
<td>Individual student rotation created by students</td>
</tr>
<tr>
<td></td>
<td>2 sessions of 25 minutes:</td>
<td>2 sessions of 20 minutes:</td>
</tr>
<tr>
<td></td>
<td>● Group instruction with teacher (2-3 times per week)</td>
<td>● 'Workshop' group instruction with teacher (2 required per week)</td>
</tr>
<tr>
<td></td>
<td>● Independent practice</td>
<td>● ‘Follow-up’ tasks independent practice (2 required per week)</td>
</tr>
<tr>
<td></td>
<td>● Computer practice</td>
<td>and student selection (within limits) of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Computer practice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Maths games</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Tasks to maintain learning from previous topic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Problem solving tasks</td>
</tr>
<tr>
<td></td>
<td>5 minutes returning to home classes at end of maths time</td>
<td>5 minutes changeover between sessions</td>
</tr>
</tbody>
</table>
Several key differences emerged between the mathematics programme in the single-cell environment and the MLE. Firstly, fixed groupings based on general mathematical ability were replaced with variable, constantly changing groupings based on mastery of specific learning objectives. There was a decrease in group instructional sessions for most students from three to two per week. One day per week the mathematics time was dedicated to organisation of the programme. This was accompanied by implementation of student-created individual timetables. Finally, teacher aide support, which had only been accessible by a single class, was now accessible by all teachers and students in the team.

While all teachers were fully committed to ensuring the programme worked effectively, they expressed varying opinions as to the reasons for making the changes. One teacher saw the changed programme growing from the need to provide more individualised learning pathways for students. Another teacher echoed this idea, describing the programme’s increased capacity to meet individual needs because of less emphasis on fixed ability groupings. In addition, this teacher saw the new programme as emerging from a desire to develop greater student agency. However, the third teacher saw the programme changes as largely driven by an expectation from school management to adopt certain practices considered desirable in a MLE.

Sub-question 1: Is there a change in the duration and frequency of teacher-student interactions in general and feedback in particular?

1.1 Duration of interactions

The duration of TSIs was established by completing a word count for each interaction from the teacher observation running record. As the Time 1 observation running record for Teacher 2 was incomplete, no Time 2 observation running record was made for this teacher. Therefore only data for Teacher 1 and Teacher 3 were used in the analysis. Each interaction was classified according to whether its duration was brief (10 words or less), short (11 to 50 words), moderate (50 to 100 words), or extended (more than 100 words). The percentage of interactions of each duration is shown in Figure 14.

The percentage of brief interactions was around 40% for both teachers in the first observation, however no brief interactions were recorded in the second observation. The percentage of short interactions decreased from 43% to 28%, being most pronounced for Teacher 3, where they fell from 36.7% to 12.5%. The percentage of interactions of moderate duration showed a large increase, climbing from an average of 8.25% to 46.9%. The percentage of extended interactions also increased for Teacher 1.
1.2 Frequency of teacher-student interaction

The overall frequency of TSI was firstly considered by combining data from teacher observations and student report via the student questionnaire. Secondly, the student report data on interaction frequency from the student questionnaire was considered independently to allow identification of any differences in reported interaction frequency by various student sub-groups.

1.2.1 Overall frequency of teacher-student interaction

The overall frequency of TSI was measured in two ways: using data from teacher observations and data from the student questionnaire. The teacher observation data and the student report data on frequency of TSI appeared reasonably consistent in that they showed no major differences in overall frequency of TSI between Time 1 and Time 2.

Teacher observation

The percentage of time spent by teachers in TSI within each observation period was calculated from the teacher observation schedule. The main audience for TSI was recorded at one-minute intervals. Total minutes spent in TSI was calculated and converted to a percentage of the total observation time. For Time 1, all teachers were involved in TSI for the entire observation period. For Time 2 there was a slight decrease in percentage of time spent in TSI for two of the teachers. Teacher 2 was involved in
TSI for 80% of the time and Teacher 3 for 83% of the time. Reference to field notes shows that at some points in the Time 2 observation, these two teachers observed while one teacher gave instructions to the whole student group. This resulted in a short period where these teachers were not involved in any interaction with students.

**Student questionnaire**

Student questionnaire data was gathered from 11 students on two occasions. The student questionnaire included six items that required students to report how frequently they experienced TSIs of various types: ‘never’, ‘hardly ever’, ‘sometimes’, ‘lots’, and ‘always’. Student responses were converted to a 1 to 5 scale, and totalled to get an overall TSI frequency score for each student. Higher scores indicated greater frequency. The overall TSI frequency scores are shown in Table 13. The aggregated data shows virtually no change in students’ reported frequency of TSI. The total score for all 11 students increased by one, the mean and median scores remained the same and the range of scores decreased by one.

Table 13

<table>
<thead>
<tr>
<th></th>
<th>Total score all students (n=11)</th>
<th>Mean score</th>
<th>SD</th>
<th>Median score</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>247</td>
<td>22.5</td>
<td>2.9</td>
<td>23</td>
<td>9 (Scores 17-26)</td>
</tr>
<tr>
<td>Time 2</td>
<td>248</td>
<td>22.5</td>
<td>2.1</td>
<td>23</td>
<td>8 (Scores 17-25)</td>
</tr>
</tbody>
</table>

**1.2.2 Frequency of teacher-student interaction by student sub-groups**

The student report data on interaction frequency from the student questionnaire was considered independently of the teacher observation data. The data for each individual student was used to consider the interaction frequency scores according to student gender, Time 1 mathematics class, and student mathematics level. Patterns of student-reported interaction frequency were noted for all three sub-groups.

**1.2.2a Frequency of teacher-student interaction by student’s gender**

Figure 15 shows the students’ individual interaction frequency scores by gender as well as the mean interaction frequency score for females and males. On both occasions females (n=5) reported
generally higher frequency of interaction than males (n=6). There was a decrease in overall interaction frequency reported by four of the five female students, with the fifth reporting no change. There was an increase in overall interaction frequency reported by four of the six male students, with the other two reporting no change. On average females recorded a small decrease in overall interaction frequency while males reported a small increase.

Figure 15. Student report frequency of teacher-student interaction by student gender: female students A-E, male students F-K

1.2.2b Frequency of teacher-student interaction by student’s Time 1 mathematics class

In Figure 16 the students’ overall interaction frequency scores are grouped according to the mathematics class they were in for Time 1 data gathering - with Teacher 1, Teacher 2, or Teacher 3. The classes were streamed by ability, with the third of students with highest-ability students with Teacher 2, the middle ability group of students with Teacher 1 and the lowest third of students with Teacher 3. A teacher aide supported the lowest ability mathematics class on a daily basis. Students from Teacher 1’s mathematics class reported either no change or a slight increase in overall interaction frequency. Those students who were with Teacher 2 reported small increases in overall interaction frequency. Four of the six students who had previously been with Teacher 3 reported
decreases in overall interaction frequency. One reported no change, while the other reported a slight increase.

Figure 16. Student report frequency of teacher-student interaction by student’s Time 1 mathematics class denoted by teacher 1, 2 or 3

1.2.2c Frequency of teacher-student interaction by student’s mathematics level

Each student’s mathematics level was represented by a single numeric value calculated from their maths entry level to Year 4 (New Zealand Curriculum level), maths GloSS stage on entry to Year 4 and Year 4 PAT stanine score. Figure 17 shows the students’ individual interaction frequency scores according to their mathematics level, in order from lowest level to highest level. The data showed a slight positive trend of increasing reported overall interaction frequency as mathematics level increased. Students with a lower than average maths level were more likely to report a decrease in frequency of interaction. Students with a higher than average maths level were more likely to report an increase in frequency of interaction.
1.3 Frequency of feedback

In the previous section, analysis focused on TSI in general, whereas in this section frequency of feedback interactions in particular are investigated. The overall frequency of feedback was firstly considered by combining data from teacher observations and student report via the student questionnaire. Secondly, student report data on feedback frequency from the student questionnaire was considered independently to allow identification of any differences in reported feedback frequency by various student sub-groups.
1.3.1 Overall frequency of feedback

The overall frequency of feedback was measured in two ways: using data from teacher observations and data from the student questionnaire. Teacher observation data and student report data on frequency of feedback appeared reasonably consistent in that they showed a decrease in overall frequency of feedback between Time 1 and Time 2.

Teacher observation

Instances of feedback in the teacher observation running record were identified using the Tunstall and Gipps (1996) typology. There being no complete Time 1 observation running record for Teacher 2, no Time 2 observation running record was made for this teacher. Therefore only data for Teacher 1 and Teacher 3 were used in the analysis. Decreases in feedback frequency were recorded for both teachers. For Teacher 1 the feedback occurrences fell from 28 to 20. However, there was a considerably larger decrease recorded for Teacher 3, from 41 to 14. This substantial decrease must be considered in light of the information from the observation schedule that showed this teacher was observed with a group of 8 students in Time 1 as compared to a group of 3 students in Time 2. This may have caused a decrease in feedback resulting from the smaller number of students worked with. The disparity in student group size between the two times was unable to be predicted when planning for the second observation. In the mathematics programme format in the MLE students chose the workshops they would attend and when. Therefore teachers had no way to determine how many students might attend each workshop. This meant the observer was also unable to anticipate the group size being observed.

Student questionnaire

Student questionnaire data was gathered from 11 students on two occasions. The student questionnaire included 11 items that required students to report how frequently they experienced feedback of various types: ‘never’, ‘hardly ever’, ‘sometimes’, ‘lots’, and ‘always’. Student responses were converted to a 1 to 5 scale, allowing calculation of an overall feedback frequency score for each student. Higher scores indicated greater frequency. The overall feedback frequency scores are shown in Table 14. A moderate decrease in reported overall feedback frequency was recorded, with the aggregated scores from all students falling from 398 to 359. The mean score fell by almost 4 points from 36.2 to 32.6. The range of scores increased considerably from a range of 10 for Time 1 to a range of 17 for Time 2.
Table 14

*Student report frequency of feedback*

<table>
<thead>
<tr>
<th></th>
<th>Total score all students (n=11)</th>
<th>Mean score</th>
<th>SD</th>
<th>Median score</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>398</td>
<td>36.2</td>
<td>2.89</td>
<td>36</td>
<td>10 (30-40)</td>
</tr>
<tr>
<td>Time 2</td>
<td>359</td>
<td>32.6</td>
<td>4.90</td>
<td>32</td>
<td>17 (23-40)</td>
</tr>
</tbody>
</table>

1.3.2 Frequency of feedback by student sub-groups

Student report data on interaction frequency from the student questionnaire was considered independently of teacher observation data. The data for each individual student was used to consider the frequency scores according to student gender, Time 1 mathematics class, and student mathematics level. There were no discernible patterns of reported feedback frequency for any sub-group.

1.3.2a Frequency of feedback by student’s gender

Figure 18 shows students’ individual feedback frequency scores by gender as well as a mean feedback frequency score for females and males. Nine of the eleven students reported less frequent feedback, one reported no change, while one student reported a slight increase. Both of the students who did not report a decrease in the frequency of feedback were male. The largest decrease in frequency of feedback was reported by a male student.
Figure 18. Student report frequency of feedback by student gender: female students A-E, male students F-K

1.3.2b Frequency of feedback by student’s Time 1 mathematics class

In Figure 19 students’ overall feedback frequency scores are grouped according to the mathematics class they were in for Time 1 data gathering - with Teacher 1, Teacher 2, or Teacher 3. The two students who did not report any decrease in the frequency of feedback were from different Time 1 mathematics classes (Teacher 1 and Teacher 3). The largest decrease in frequency of feedback was reported by a student from Teacher 1’s class. The only student to report an increase in frequency was also from Teacher 1’s class.
1.3.2c Frequency of feedback by student's mathematics level

Each student's mathematics level was represented by a single numeric value calculated from their maths entry level to Year 4 (New Zealand Curriculum level), maths GloSS stage on entry to Year 4 and Year 4 PAT stanine score. Figure 20 shows students' individual feedback frequency scores according to their mathematics level, in order from lowest level to highest level. Students with large decreases in reported feedback frequency and students with the small decreases in reported feedback frequency were represented in both higher than average, near the average and lower than average mathematics levels.
Sub-question 2: Is there a change in the type of teacher-student interactions in general and feedback in particular?

Comparative data on different types of TSIs and feedback were gathered using a variety of measures. Firstly, using a coded observation schedule, TSIs were considered solely as to the type of audience the teacher interacted with during the observation period, with type being defined by the size of the audience. Secondly combined data from running records of teacher observations and student report via the student questionnaire was used to consider the types of TSI according to their function. Finally, combined data from running records of teacher observation and student report via the student questionnaire was used to compare the prevalence of different types of feedback.

2.1 Teacher-student interaction by audience type defined by size of audience

Using the teacher observation schedule the main type of audience interacted with was recorded at one-minute intervals. Codes indicated whether teachers were working with no students, an individual (1 student), small group (2-8 students) large group (9-20 students) or the whole class (21+ students). For each teacher observation the amount of time attributed to each audience code was calculated as a percentage of the total observation time of 30 minutes. These percentages are shown in Figure 21.
Between Time 1 and Time 2 there was a slight increase in teachers not engaged in interaction with students. A decrease in individual interaction was recorded. There was a large decrease in teachers working with small groups, which was possibly offset by the increase in large group interaction. The percentage of whole class interactions fell but this may be attributable to the field note, which recorded that the usual whole class ‘warm-up’ was not held on the day of the Time 2 observation. The amount of time teachers spent roving increased substantially between Time 1 and Time 2.

![Graph showing teacher-student interactions](image)

**Figure 21.** Observed teacher-student interactions by audience type according to group size represented by number of students: no students; individual (1 student); small group (2-8 students); large group (9-20 students); whole class (21+ students).

### 2.2 Teacher-student interaction type defined by function

From the literature review, three types of student-interaction were identified - those that provide instructional support, organisational support or emotional support (Hamre & Pianta, 2007). Definitions of these three types were used as a basis for the measures and the data analysis of TSI type. There were considerable differences between observed data on TSIs and student-report data. While student-report data showed fairly similar amounts of each type of interaction between Time 1 and Time 2, there were substantial changes in observed teacher interactions of each type, with the amount of instructional interactions increasing, and organisational interactions decreasing.
Teacher observation

An observation running record was completed for two of the three teachers for a 30-minute period in both Time 1 and Time 2. Only data for Teacher 1 and Teacher 3 were used in the analysis as there was no complete Time 1 observation running record for Teacher 2. Therefore no Time 2 observation running record made for this teacher. TSIs within the observation running record were classified according to the main type of support provided to students by that interaction. These were then converted to a percentage of total TSIs for each teacher, and overall across both teachers, as shown in Figure 22. Overall instructional interactions showed substantial increases, coupled by a large fall in organisational interactions. No emotionally supportive interactions were observed in Time 2 for either teacher.

![Figure 22](image)

Figure 22. Observed teacher-student interactions by type of support provided.

Student questionnaire

There were six items on the student questionnaire that required students to report how often they experienced TSIs of various types, two items for each of the three types. Students reported the frequency of particular interactions occurring as: ‘never’, ‘hardly ever’, ‘sometimes’, ‘lots’, and ‘always’. Student responses were converted to a 1 to 5 scale, allowing calculation of an overall frequency score for each type of TSI. These scores are displayed in Figure 23. On both occasions, students reported organisational interactions as occurring most frequently. There was minimal change between Time 1 and Time 2 for the three types of interaction.
Figure 23. Student report teacher-student interactions by type of support provided.

2.3 Feedback type

From the literature review the typology created by Tunstall and Gipps (1996) was selected as the basis for the measures and the data analysis of feedback type. The four types are summarised in Table 15.

Table 15

Summary of feedback types

<table>
<thead>
<tr>
<th>Type</th>
<th>A1</th>
<th>Evaluative</th>
<th>Positive feedback</th>
<th>Rewarding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A2</td>
<td>Evaluative</td>
<td>Negative feedback</td>
<td>Punishing</td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>Evaluative</td>
<td>Positive feedback</td>
<td>Approving</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>Evaluative</td>
<td>Negative feedback</td>
<td>Disapproving</td>
</tr>
<tr>
<td></td>
<td>C1</td>
<td>Descriptive</td>
<td>Achievement feedback</td>
<td>Specifying attainment</td>
</tr>
<tr>
<td>Type</td>
<td>D1</td>
<td>Descriptive</td>
<td>Achievement feedback</td>
<td>Constructing achievement</td>
</tr>
<tr>
<td>------</td>
<td>----</td>
<td>-------------</td>
<td>----------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>D2</td>
<td>Descriptive</td>
<td>Improvement feedback</td>
<td>Constructing the way forward</td>
<td></td>
</tr>
</tbody>
</table>


There were differences between teacher observation and student report data. While only one instance of Type S feedback, and no instances of Type A or Type D feedback were observed in either observation, students reported experiencing all those types of feedback. Students reported decreases across all types of feedback while teacher observation data showed a decrease in Type B feedback and an increase in Type C feedback.

Teacher observation
Instances of feedback in the teacher observation running record were identified and classified according to type. These were then converted to a percentage of the total feedback instances for each teacher, and overall across both teachers, as shown in Figure 24. In both observations and for both teachers, Type C feedback was the most prevalent. Type C feedback also showed moderate increases between Time 1 and Time 2. This was matched by corresponding decreases in Type B feedback. No instances of Type A feedback were recorded on either occasion. There were no examples of Type D feedback recorded. Only one instance of Type S feedback was recorded over both observations.
Student questionnaire

The student questionnaire included 11 items that required students to report how often they experienced feedback of various types, indicating the frequency of particular feedback occurring as: ‘never’, ‘hardly ever’, ‘sometimes’, ‘lots’, and ‘always’. Student responses were converted to a 1 to 5 scale, allowing calculation of an overall frequency score for each type of feedback. The student report of frequency for each type of feedback is shown in Figure 25. On both occasions students reported Type D feedback as being the most frequent, and Type A feedback the least frequent. Students reported a drop in frequency for all types of feedback between Time 1 and Time 2. The largest decrease was for Type D feedback and the smallest decrease for Type C feedback.
Sub-question 3: Do teachers and students perceive any change in teacher-student interactions and feedback?

Three teacher and 11 student participants were interviewed on two occasions. Time 1 questions were used to establish baseline data by probing participants’ understanding of and current perceptions of TSIs and feedback. Time 2 interviews included questions that explored the changes they perceived in transitioning to the MLE setting. The results in this section are organised according to whether they reflect teacher or student perceptions of TSI and feedback.

3.1 Teachers’ perceptions of changes in teacher-student interactions

The results in this sub-section are organised firstly according to whether they reflect teacher perceptions linked to instructionally, organisationally or emotionally supportive interactions, and then according to themes that emerged from the coding of the data.
3.1.1 Instructionally supportive interactions

Time engaged in instructional interaction

Teachers’ perceptions of the amount of time engaged in instructional interactions matched the data from the observation schedule. All reported being involved in instruction in one form or the other for the entire mathematics lesson, with virtually no ‘down time’. As one teacher stated, “... everyone is actively engaged in teaching Year 4.” There was a sense of pride in the whole team effort to maximise instruction and achieve positive outcomes for students. Mention was also made of the accountability that resulted from the de-privatisation of practice in the MLE, with one teacher commenting, “Making sure that people aren’t just doing, you know – ‘I’m tired today, kids just do Mathletics for half an hour’ – everyone has to do their lesson.” However, teachers also reported their greater ability to support others in the team to provide quality instruction at times of pressure. For example, one said “(Teacher) and I have driven it but that’s because (teacher) is focusing on the production, so we’ve said that we’ll run it and you can fill in,” and, “If you’ve got a beginning teacher or someone that’s unsure you can almost have a couple of people running it and organising it and they can slot in when necessary.”

The changed context of instructional interactions

While teachers felt that time spent in instructional interactions remained unchanged, they perceived that the context of those interactions altered considerably in the MLE. They reported that time spent in formal group instruction had decreased. Formerly they took group lessons for the majority of the mathematics time. One teacher described this, saying ”I guess normally (in the previous setting) what I would do is have two to three groups in an hour so I would have no roving time really.” This decrease in group instruction was balanced by the opportunity for more informal individual instructional interactions with students in the role of roving teacher. For the most part they saw this role as having a positive impact on instruction. The dual nature of this impact is exemplified in this quote from one teacher - “I think that this way, I've got a lot more time to rove, talk to people. Those that are working on follow-ups have time to come and talk to a roving teacher, instead of feeling that they're interrupting a teaching group.” Not only did teachers feel they had more time to interact with individual students, the roving teacher also allowed those engaged in group teaching to do so uninterrupted. As one teacher described “... when I was doing group teaching in the single cell classrooms, my class would still come and interrupt me and say (Teacher) I need help - but if it's a workshop, the kids know that's a workshop and they can't interrupt - they haven't attempted to come and ask for help. They go to the roving teacher because there's always two teachers roving and available.” However, the decision to have one teacher roving at all times had created some difficulty in ensuring that sufficient group workshop times were available for students to receive instruction. Two teachers mentioned the need to revisit the organisation to allow students to fit in three group workshops per week, rather than the current two.
Increased student-initiated instructional interactions

Another change mentioned numerous times was an increase in student-initiated instructional TSI. Students opted to attend workshops that they knew would support their learning, with some going beyond the results of the pre-test to do so. One teacher talked about this, saying “What’s cool about it is we have seen a lot more agency happening because within the tests some of them just guessed the answer and they got it right. We said to them that if you look at that, can you actually answer it, do you know how you arrived at the answer, and if not then you need to go to the workshop. A lot of them have come up to me and said, ‘Actually (Teacher), I know I got it right but I guessed it’ or ‘I’m not sure how I got it’, which has been awesome.” Students were noted as initiating interactions with the roving teachers to seek clarification, obtain further instruction or gain feedback about their learning. Teachers reported this occurring with increasing frequency - “The students are slowly getting used to coming up and saying ‘I don’t get this’ or ‘I need to get this signed off’.”

Changed content of instructional interactions

Teachers spoke about changes in the content of group instructional interactions. Lessons were tightly focused on one specific concept or skill from the pre-test. As one teacher noted, this presented some challenges and had both positive and negative elements: “I think it’s incredibly targeted teaching. You’ve only got a limited amount of time. I have the tendency to ramble on quite a bit. In the workshops you have to get to the point and make the point really clear and you know you’ve only got 20 minutes before you change. In that way, it has been hard because we’ve all said we need more time. But at the same time, it’s incredibly targeted focusing on one little aspect. When I was group teaching, I would cover quite a few different things (Interviewer: and you would go off on a tangent perhaps…) Yes and that wasn’t necessarily a bad thing but you can’t do it in the workshop - we’ve got to talk about just this one thing and nail it.” Another teacher spoke about the narrowing of the content of group instructional interactions as impacting negatively on the teacher’s ability to develop concepts “… you need to revisit that concept but perhaps with additional challenges … that might be equivalent ratios instead of equivalent fractions. Or your fractions have much more difficult denominators to deal with.” Additionally teachers felt that it was challenging to make connections for students between one instructional workshop and the next as they may cover very different aspects of the topic, for example: “Fractions is a bit harder because some of the kids are attending workshops that covering things like – what’s 4/6’s of 16? 4/6s of 24? But then coming to the decimals one next and getting really confused.”

Fluidity of groups for instructional interactions

The fluid nature of groups was seen as positive by some teachers - “It’s all about agency and collaboration and no longer saying that you’re in this group forever – it’s fluid”, but this was not without its challenges. The main challenge presented by the fluid nature of groups was the teachers’ need to
tailor instructional interactions to a group of varying sizes and levels but one that could not be planned for, as exemplified in these two quotes:

“Sometimes we get 20 and sometimes we get 3. It’s quite unexpected as are the levels within that.”

“I think that we've pre-tested the kids and we're doing a workshop for a particular thing but I've had kids who are a Stage 4 struggling and a Stage 6 who are in the same group.”

Another discussed how having different groups all the time impacted negatively on the teacher’s ability to follow up from group instruction. When asked if this created a lack of continuity - “Well yes, because then they vanish and I don't know where they are.”

3.1.2 Organisationally supportive Interactions

Teachers spoke about major differences in the organisational interactions they have with their students. Previously, in their single-cell environment there was an organisational time at the beginning of each maths lesson where teachers would discuss the plan for the day with students. No written organisation for the mathematics session e.g. a plan for group rotations, was observed in any of the classrooms. It appears that all largely relied on verbal organisational interactions to ensure the smooth running of the lesson times. In the MLE organisational interactions were generally concentrated in the Monday planning session where teachers worked with students to create an individual timetable for the week. In this time teachers discussed a written timetable that was displayed on the wall. This indicated the workshops that would be offered during the week. They also presented the independent activities available to students outside of workshop time and gave instructions for them. Teachers had varying opinions as to the amount of verbal organisational interactions required to support students during the Monday planning time. One teacher when asked if substantial teacher support was required at this time said “No, at the beginning, on that first Monday I think I only had maybe three kids that were confused, the rest of them were just like ‘Oh yep, I know what I'm doing’ and they just nailed it which was awesome. They've almost got to the point where they timetable with each other...” Whereas another teacher thought “I don't think they're managing it very well yet. It's taking me a whole maths time to get through them just doing their plan for the week.” There was similar variation in teacher views about the amount of organisational interactions that occurred during the remainder of the weekly programme. Teachers were asked if students were able to use their individual timetables independently or required teacher assistance with organisational details. One believed that it was becoming less prevalent, saying “Yeah, I think the verbals are getting less … there’s definitely less talking going on. I would expect that that would get less and less.” However another felt that the roving teacher was still providing a large amount of organisational support, responding “Yeah, because you're saying what question are you doing, show me the sheet you're doing, etc., etc.” There seemed
to be agreement that a greater amount of organisational support was required for some students. All teachers expressed concern about these students at some point in the interview, for example:

“[There are] Plenty of challenges, especially with the lower kids. Because we are finding that quite a few of them are just sitting there if they don’t know what they’re doing…they’re missing workshops and things. That is where it is getting difficult.”

“There are certainly some students that are struggling still. But I also think that they’re the same students that often rely on the teacher to help them with every process so I think independence-wise they’re going a lot better.”

One teacher expressed pleasant surprise as to how little organisational interaction had been required to support some students, saying “Then there’s the surprising ones that got it all done, got exactly everything done …”. This teacher saw the reduced need for organisational support as evidence of these students progress in the New Zealand Curriculum key competency of ‘managing self’.

3.1.3 Emotionally supportive interactions

Teachers had differing views on their ability to give sufficient emotional support to students in the MLE. One teacher expressed confidence in having a fairly good knowledge of the whole team group. Another felt that development of teacher-student relationships was a strength at the school and that this allowed students to be receptive to engaging in emotionally supportive interactions with all teachers in the team. However, the third teacher expressed doubts about their ability to give emotional support to students from their original home classes, saying “That has actually been quite hard. I had my own class at the beginning of the year and obviously I feel like those are my kids. But there’s people like (student) and (student) I never see or teach anymore …they come to me in the morning and I say ‘How are you guys? I haven't seen you in awhile’ - I guess it is just stopping and making sure that you say hello.” One teacher raised concerns about the impact of working with multiple teachers on the emotional support of some students, saying “I think some of the students probably need someone more consistent…lesser-abled students are probably struggling a little bit with not having the consistency of having one person to talk to, of having one person to ask questions to.”

3.2 Teachers’ perceptions of changes in feedback

The results in this sub-section are organised according to themes that emerged from coding of the data.
Context for feedback - group to individual

Teachers’ comments on feedback to students in Time 1 interviews suggested that the majority of feedback was verbal. Most took place within the context of group instructional times. This was a mixture of feedback in response to students’ verbal responses to questions about their thinking in relation to the concept or problem, or feedback in response to discussion of answers in group marking sessions. Some individual feedback took place when teachers found time to rove amongst students working independently, however both observations and interviews suggested this was a small proportion of teacher time. In addition some individual and group feedback was given in relation to student’s achievement of goals recorded on sheets in their mathematics book. This tended to happen most often near the end of the term, particularly in the lead up to learning conferences. These were held at the end of Term 2. Students discussed their learning goals with their parents at this time.

Following transition to the MLE, teachers reported that verbal feedback continued to be the norm. However, there were some changes to the context for feedback. While teachers continued to give feedback during group instructional times as they conducted workshops, marking of independent work no longer took place in a group. Rather this had become part of the roving teacher role. Roving teachers marked students’ follow-up tasks with them and gave feedback as to whether it was sufficient evidence of understanding the concept or skill embedded in the task. The roving teacher indicated the student’s successful understanding of that concept or skill by signing against the relevant question on the student’s pre-test sheet. It was expected that students would normally require three signatures to show sufficient mastery of the concept or skill. There were varying opinions as to the effectiveness of this method for giving feedback. One teacher described a positive outcome as being “(It is) almost instant reward for the kids – when they see that signature then they know that they’ve done well in that workshop.” However another stated her preference for the previous system, saying “I do like marking in a group again at the end and coming together. That way I know who didn’t get something right and I know that I need to revisit that concept with that whole group or just one or two kids.” This teacher felt that marking on the spot with individuals not only made it difficult to track the understanding of students from the instructional workshop, but created a time pressure for the roving teacher, saying “You can’t mark dozens of kids during a 15 - 20 minute session.” Other teachers felt that roving gave them more opportunity to give feedback, saying “I can get to anyone that I need to get to when I have my roving session. So I am able to get around and see more people.”

Feedback on learning goals

Teachers also noted that the nature of feedback against learning goals had changed. Rather than a less frequent focus on broad longer-term goals, they were now giving frequent feedback about specific goals related to the current topic. These goals were the areas of learning indicated by the topic pre-test. One teacher discussed this with the interviewer:
“Interviewer: So it’s quite specific to a learning objective?”

“Teacher: Yeah, I think so. We did have learning objectives before but it was over a much longer period of time where we did have a sign off sheet at the back. But it was more general then, not as specific as now.”

3.3 Students' perceptions of changes in teacher-student interactions

The results in this sub-section are organised firstly according to whether they reflect student perceptions linked to instructionally, organisationally or emotionally supportive interactions, and then according to themes that emerged from coding of the data.

3.3.1 Instructional interactions

Teacher time
In Time 1 interviews students appeared satisfied with the amount of time spent interacting with teachers, while showing understanding of the reasons why it most often had to be in a group setting because of student numbers. In Time 2 interviews students had varied opinions as to whether they had the same, more or less teacher time in the MLE. However, just as in the previous interviews, all seemed to accept this as the way it had to be because there were many students to one teacher. The students who felt they had more teacher time in the MLE identified the way the class was managed as a factor in maximising teacher time for students. They mentioned greater student independence and more roving teachers as contributing to this.

Teacher assistance
In Time 1 interviews students frequently reported either using independent strategies if they had difficulties or seeking assistance from their peers. Teachers involvement in teaching groups meant they were less likely to identify a teacher as a source of assistance. They seemed to have an attitude of self-reliance in solving problems. However in the MLE most students (n=9) identified the roving teacher as their first choice when seeking assistance.

Context for instructional interactions
In the Time 1 interviews students generally talked about instructional interaction in terms of group interaction. However in Time 2 interviews, some students (n=5) mentioned the roving teacher, as a source of instructional interaction although they all continued to see workshop groups as the key place for receiving instruction.
### 3.3.2 Organisational interactions

In Time 1 interviews, little mention was made of teacher organisational interactions. In contrast, during Time 2 interviews all students spoke at length about organisational TSIs linked to the creation and use of students’ personal timetables.

### 3.3.3 Emotional interactions

Very little mention was made of emotionally supportive interactions at either interview. There were brief comments about teachers being supportive, encouraging a positive attitude, and wanting to help them learn.

### 3.4 Students’ perceptions of changes in feedback

The results in this sub-section are organised according to themes that emerged from coding of the data from Time 1 interviews, where students identified three major sources of feedback. Changes to each of these sources of feedback was reported in Time 2 interviews.

#### Feedback through marking of work

The first feedback source was marking of work. In Time 1 this was generally done by students, but in a group setting. Although sometimes the teacher might mark away from the students e.g. when marking tests, such marking was frequently reviewed with the teacher in a group. The students spoke about coming together to discuss common errors and go over the concepts or strategies again. In Time 2 interviews all students identified the ongoing feedback provided by the marking of follow-up tasks and signing of test summary sheets. However this was done individually, usually by the roving teacher.

#### Feedback on learning goals

A second source of feedback from Time 1 were student goal sheets. Students mostly spoke about these as being referred to at specific times of the year e.g. prior to learning conferences, when the teacher would give feedback against them. However, some students (n=5) mentioned referring to them in regular class time. Responses to Time 2 interview questions showed the same perspective - that goal sheets were not referred to very often. However in the MLE, most students (n=9) saw their most important goals as indicated by the questions they got wrong on the pre-test. They explained how specific goals for the topic were on the test summary sheets. Students spoke about the requirement to gain positive feedback (get them signed off) on three occasions as evidence of having achieved them.
Feedback during the lesson

In both sets of interviews, students identified teacher responses occurring within the lesson as a way they received feedback about their ongoing learning.

Sub-question 4: Do teachers and students identify a change in the factors that act as barriers and enablers to teacher-student interactions?

During the two sets of interviews, the three teacher and 11 student participants were asked about barriers and enablers to TSI. Time 1 questions explored the existing barriers and enablers. Participants were also asked to suggest possible additional enablers. The Time 2 interview included questions that explored their current perceptions of previously identified barriers and enablers after transition to the MLE setting. In addition participants were asked to identify any new barriers and enablers identified in the MLE setting. The results in this section are firstly organised according to whether they reflect teacher or student perceptions of barriers and enablers of TSI and feedback. The results in each sub-section are further organised according to whether they reflect barriers or enablers, and then finally under themes that emerged from coding of the data.

4.1 Teachers’ perceptions of changes in barriers to teacher-student interaction and feedback

Time with individual students

During Time 1 interviews teachers identified time as the greatest barrier to effective TSI and feedback. Some saw paucity of time as impacting on the amount of interaction with individual students. One summed up her feelings by saying “... because to be honest I hardly ever meet on an individual basis with the kids - you only ever see them on a group level so it’d be really nice to sort of have time to discuss with those children on an individual basis, just to make sure they’re definitely getting it. There are times when you are able to keep them with you but the majority of the time it is tricky to manage that. So having more of individual (interaction) would be good.” In the second interviews, there was a general feeling that the move to the MLE had somewhat removed this barrier. All teachers were timetabled to be the roving teacher and most appreciated the extra opportunity to interact individually with students. The same teacher who previously spoke of the lack of individual interactions had this to say: “When they come up to you in the roving period and they say I need to sign this off, we talk to them about how we're signing it off and how they got the answer and those sorts of things. You are having these little snippets with just that one individual kid and they have to come to you to do it. That's not every kid but between us, we all will see kids on an individual basis every day.”
Time to ensure curriculum coverage
Another concern raised in Time 1 interviews was that limited time acted as a barrier to effective coverage of the full range content within the mathematics curriculum. One teacher expressed a belief that non-number areas of the curriculum such as geometry and measurement were frequently neglected due to the pressure to cover number concepts. When asked about this barrier in the MLE context, the teacher felt that this barrier had been somewhat overcome by the programme operating in the MLE.

Time for feedback to students
Lack of time to discuss student goals and give high-level feedback was also considered a barrier in Time 1 interviews. There was a feeling that time spent doing this to the extent that it should be done would result in taking time away from other valuable activities. One teacher reflected that “It takes a long time to build in the ability to talk about goals and to talk about what they’re doing and to spend that time with the students actually teaching them those things.” In the MLE, the implementation of the topic pre-test as a method for setting goals and an emphasis on students selecting the learning needed to meet those goals suggested that this barrier may have been minimised. One teacher commented “It’s using their own results to try and seek out new knowledge, which has been fantastic.”

Number of students
A new barrier that emerged in the course of the second round of interviews centred around teacher knowledge of students. All teachers expressed concern at how the greater numbers of students in their care limited their ability to give effective instruction and feedback, as it limited the depth of their knowledge about students. They described this by saying:

“I feel as though you know more children but that you know less of them because you’re spread. If I had my 24, I feel as though I would know them better.”

“You do have 68 kids and I don't have a grasp on each and every one of them. Not even close. I mean I know a select few, how their maths is - but I think it is a lot harder.”

“I knew my maths class really well last term, because they were my maths class and I had them every day. Whereas now...it's everybody. And it is hard. We do really need to develop a better tracking system. And do a lot more research into that.”

“I can't track some of my kids anymore, I don't know where they are and what they're doing.”
Complexity of planning and organisation

Another new barrier was the complexity of planning and organisation required. Although teachers had an overview of the needs of students as indicated by the pre-test, timetabling of the workshop groups proved challenging, as one teacher states: “The hard stuff is organising the workshops and knowing which workshops to put in. I guess that comes from tracking as well and understanding what the actual needs of the students are.” As time went on this complexity escalated with some students ready for new learning, while others required repetition of workshops to achieve understanding. Teachers also expressed concern about the non-linear nature of learning objectives and the resulting challenges of catering for students instructionally. This added to the complexity of planning adequately for instructional interactions, as described by one teacher: “Normally they would go through more of a linear process, from easy to hard. At the moment what’s happening is that there’s some easy questions that they are doing and then the next ones are not available for workshops. So they’re jumping from something that’s either quite different, e.g. fractions to decimal problems. Or it could be that they were working on finding fractions with a group and then they’re jumping to something else with fractions which doesn’t quite relate.” One teacher wondered if the barrier of planning complexity might be overcome by access to expertise from other schools who had already made a successful transition to teaching in a similar environment - “Someone with more probably knowledge of how to make it work, a little bit more guidance. Because we’re going to end up spending half a month, a month trying to work something out when in fact if someone just came in and led you a little bit more with it. I definitely think that there’s a space for someone, within your cluster of schools, to say – we’re doing this and we pay (another school) a week’s reliever and someone comes in and leads everyone’s maths.”

4.2 Teachers’ perceptions of changes in enablers of teacher-student interaction and feedback

Planning

In Time 1 interviews, teachers described careful planning as an important enabler to effective interaction with students. In the MLE, the collaborative planning required for the larger number of students continued to support effective TSI and feedback, however, this came with some considerable challenges as discussed in the section on barriers. A key tool that teachers identified as an enabler was the pre-test for the topic and the individual summary sheet for each student produced from this. The overall picture of student knowledge of the topic provided a blueprint for planning relevant instructional workshops. The student summary sheets acted as a guide for teachers when students sought assistance or feedback, allowing teachers to respond specifically to the area of need.

Time management

Another aspect of this careful planning was time management. In both Time 1 and Time 2 interviews teachers spoke how managing time well allowed for successful instructional interactions. However,
teachers spoke about a greater focus on specific learning objectives emerging from the topic pre-test as an enabler to managing their time effectively in the MLE.

**Student engagement**
Teachers reported student engagement as an important factor in successful TSI. Engagement was considered a means to ensure that students involved in independent tasks did not interrupt instructional interactions. In Time 2 interview two teachers described increased student engagement in the MLE. They suggested this greater engagement was a result of students having more choice in their learning. Another factor identified as contributing to greater engagement was an increased emphasis on growing student skills in self-management and leading their own learning.

**4.3 Students’ perceptions of changes in barriers to teacher-student interaction and feedback**

*Noise and distractions*
In Time 1 interviews some students (n=3) identified barriers to interaction created by other students such as noise and distractions. In Time 2 a similar number of students (n=4) mentioned noise from other students in their team and classes from other teams as a barrier to learning. One described how she found it difficult to hear what teachers were saying and the noise distracted them from listening.

*Insufficient access to teacher assistance*
Some students (n=2) in Time 1 interviews mentioned the teacher’s inability to respond to student needs for assistance because they were teaching groups. They described how this acted as a barrier to receiving the frequency of TSI they would like and the timeliness of interactions. By Time 2 most students (n=9) saw this barrier as no longer existing due to much improved access to teachers provided by the role of the roving teacher.

*Inappropriate levels of work*
In Time 2 interviews some students (n=2) spoke about barriers to TSI in their previous classes as being created by inappropriate levels of work. In particular they described work that was too easy as a contributing factor to noise and distraction coming from disengaged members of the class. In the MLE these students reported the value of greater homogeneity in instructional groups in overcoming this barrier. This is exemplified in the following conversation between the researcher and one student:

Interviewer: Last time you told me that sometimes people distract you and that made it harder in maths. Do you think that in this new space you find people distract you more, or the same, or less?
Student: Well, less usually because in the workshops, we all don't know that thing. In a class there are people that know it, so they just distract you.
Interviewer: So in your other class, sometimes when you were in a group there were people in that
group who already knew what you were learning, so they were just mucking around.
Student: Yeah because they didn't need to know that.
Interviewer: Whereas, now in your workshops, everyone wants to be there and needs to be there. They're really focused on learning that thing.
Student: Yeah. And if you do know it, you shouldn't be in that workshop.

4.4 Students' perceptions of changes to enablers of teacher-student interaction and feedback

Planning and organisation
Students saw the way teachers plan and organise instructional interaction as a key enabler. In Time 1 their comments centred around the sharing of teacher’s time between interaction with different groups of students. Having moved to the MLE, students identified a number of new tools and practices that contributed to planning and organisation. Firstly they saw the planning of the weekly timetable and their use of it as enabling to them to connect with their teachers in ways that would assist learning. The pre-test summary was also identified as an enabler which ensured that students knew exactly which opportunities for instructional interaction they needed to take up. The pretest summary was also an enabler of feedback. Students spoke about initiating interactions to gain feedback about their learning goals. Students talked about how, having decided that they understood a concept, they would then seek out a teacher to discuss evidence of this understanding.

Homogeneity of instructional groups
Greater homogeneity of instructional groups was also mentioned as an enabler. One student described the impact of more tightly focused instructional interactions in this discussion with the interviewer:

Student: But it's a lot more helpful...it's easier.
Interviewer: It's more helpful?
Student: Yeah...
Interviewer: Why do you think that is? What makes it more helpful for you with the teachers?
Student: Um...because...
Interviewer: What's different perhaps...with the teachers and the way they are working that is better?
Student: They used to have different groups and everyone was working on different things in our old space. But now, everyone's working on the same things, not just different things. If I visit (Teacher)'s workshop, we would all be working on the same thing.
Interviewer: Oh ok, so in your workshop group, you all need to learn that one thing so it's very much the same. Whereas in your old group, there might be some who were already quite good at that thing and some who found it really hard still.
Student: Yeah
Access to teachers

All students identified their enhanced ability to access teachers in the MLE, largely enabled by the role of the roving teacher.

Summary

In summary, the results showed that transition to the MLE did have an impact on TSI and feedback. Changes were noted between Time 1 and Time 2 across teacher observation and student report data, as well as in the perceptions of teachers and students within the interview data. In some cases the data was consistent between sources. In other cases there were distinct differences, such as between teacher observation data and student report data around feedback. Additionally some data showed trends for particular sub-groups within the student group. Similarly, some marked differences in the perceptions of participant teachers were evident.

In the MLE there was a trend for TSIs to be of longer duration. While the overall frequency of TSI remained fairly similar, female students and lower-achieving students reported less frequent interactions. Instructional TSI tended to be more often with larger groups of students. While observed instructional TSI increased, organisational and emotionally supportive TSI decreased.

In the MLE, frequency of feedback across all types decreased, in particular the co-constructed descriptive Type D feedback.

Teachers perceived that while they remained actively teaching for the entire mathematics lesson in the MLE, the context for instructional TSI, including feedback, had changed with less formal group TSI and more informal individual TSI. Additionally students now initiated a large amount of instructional TSI and feedback interactions. Instructional groups were increasingly fluid. Both the content of instruction and feedback became more tightly focused. Organisational TSI was seen as less frequently required. Teachers were of mixed opinions as to their ability to effectively provide emotionally supportive TSI in the MLE.

Students perceived greater time with and access to teachers in the MLE through their ability to approach a roving teacher for assistance. They also valued the perceived greater organisational TSI that allowed them to create individual timetables. Students noted that in the MLE feedback about goals was now specifically linked to their pre-test summary sheet and usually gained through interaction with a roving teacher.

Teachers perceived that a number of barriers to TSI and feedback around time were reduced in the MLE. However, the greater numbers of students created a barrier to ‘fine-tuning’ TSI and feedback.
through less in-depth knowledge of students. The complexity of planning and organisation required in the MLE was another barrier to emerge from higher student numbers.

Students identified effective planning and organisation as a key enabler in the MLE. Enhanced access to teachers was another enabling factor. A final student perception of interest was the contribution greater homogeneity of groups in the MLE made to improved TSI. Some students identified this as a factor in reducing noise and distractions as well as ensuring the instructional TSI in group sessions was more helpful.

**Conclusion**

This study found that the transition of teachers and students from single-space single-teacher learning environments to a MLE had an impact on a variety of aspects of TSI and feedback in mathematics. The duration of TSIs increased, while there was a decrease in frequency of TSI for particular sub-groups of students. Instructional interactions increased as organisational interactions decreased. An absence of emotionally supportive interactions was noted in both contexts. A decrease in feedback interactions was noted across all feedback types. Teachers reported an increase in TSI between teachers and individual students, and a trend of increasing student-initiated TSI. Students similarly reported changes to the contexts for instructional interactions, including feedback. There was a major change in the way students were arranged for instruction. This resulted in instructional TSI tending to occur in groups of larger size. These groups were fluid in their composition but more homogeneous in the mathematics level of students within them. Both teachers and students identified this homogeneity as an enabler of effective instructional TSI. However, teachers considered that the number of students and the organisational complexity required to cater for their needs were barriers to TSI. The next chapter will discuss the relevance and implications of these findings.
Chapter 5: Discussion

This chapter will consider the findings of the study and discuss their implications. The identified limitations of the study are presented. Possible future research directions that emanate from the findings of this study are suggested.

The main question posed in this research asked what impact a transition to an MLE might have on TSI. The study found that there was an impact, with notable differences in TSI between the two settings. The changes in TSI that occurred largely stemmed from substantial differences between the type of mathematics programme operated in the two learning environments. These differences tended to be mediated by the changed practices adopted by teachers within the MLE, rather than the physical environment of the MLE itself. This finding is consistent with a theme identified in the literature review which suggested that effective use of the physical elements of a learning environment is highly contingent on the pedagogical practices that evolve within it.

The first sub-question asked whether there might be an impact on the duration and frequency of TSI and feedback. The second sub-question explored the possibility of the types of TSI and feedback being altered in the transition to a MLE. The findings indicated that the duration, frequency and type of TSI and the frequency and type of feedback did change in the MLE.

Duration of teacher-student interaction

The data showed a trend of a decreasing percentage of shorter interactions while longer interactions increased. This may be the result of instructional sessions in the MLE being largely free of interruption, which seems likely to impact positively on teachers’ ability to deliver quality group instruction. However, another explanation for the increasing duration of interactions is that teachers adopted a less interactive style of teaching in the MLE workshop sessions. This is supported by the greater number of instructional interactions observed within the lesson times. Arguments can be found both for and against such an approach to instruction. The development of mathematical discourse and its ability to enhance student understanding is promoted by many authors (Anthony & Walshaw, 2009; Chapin, O’Connor, O’Connor & Anderson, 2009; Hunter & Anthony, 2011; Stein, Engle, Smith & Hughes, 2008; Walshaw & Anthony, 2008). However, direct instruction was calculated by Hattie (2009) as having a reasonably high effect size (d = 0.59 overall, and d =0.50 for mathematics). Hattie believes the use of explicit learning intentions and success criteria in direct instruction is a major contributor to this effect size. Evidence of more explicit learning intentions and success criteria was observed in the MLE. Therefore, a less interactive teaching style is a possible unexpected effect of the more specific focus for each lesson. However, it may also stem from the organisational structure of the programme. Teachers reported that pressure to explain a specific concept in the allotted time, led
them to limit extended mathematical discussion on the concept or other related topics that might emerge.

**Frequency of teacher-student interaction**

While the change to the MLE appears to have had no major impact on the overall frequency of TSI, closer examination of the data shows a variation in the degree of impact on some groups of students. Teacher-voiced concerns about the programme not working effectively for all students tend to support this finding.

*Female students compared to male students*

The differences between reported interaction frequency between females and males were different to that which might be expected given the literature on the subject. Numerous studies report boys receiving greater amounts of classroom interaction (Bailey, 1993; Duffy, Warren & Walsh, 2001; Holden, 1993; Hopf & Hatzichristou, 1999; Jones & Wheatley, 1990). In this study, female students reported higher frequency of interaction in both environments. However the difference in frequency between females and males was reduced after moving to the MLE. One possibility is that the MLE magnifies factors that contribute to boys receiving more interactions and girls less. Teachers identified interactions in the MLE as more likely to be student-initiated. It may be that boys were more proactive than girls at initiating interactions with their teachers. In a study by Dukmak (2010) boys in all student groups were found to initiate more interactions than girls. The data showing reduced interactions for females in the MLE must also be considered in light of the fact that females were overrepresented in the lower-achieving student group. All five female students were at or below the median achievement level. The limitations of a small sample and no higher-achieving females in the sample group may well have influenced the gender comparison. There is a possibility that the result was not because they were female but rather because they were lower-achievers.

*Lower-achieving students compared to other students*

The data on lower-achieving students suggests that the MLE may disrupt the traditional patterns of instructional interaction seen in other studies. A number of authors (Babad, 1990,1992; Brophy, 1983; Weinstein, 1985,1989) report that low achievers receive more instruction and more learning support than high achievers. This proposition was supported in Time 1 data from the single-cell environment, but in the context of the MLE the converse was apparent with lower-achieving students reporting less frequent interaction than higher-achieving students. Teacher interview data supports this finding, with all teachers identifying lower-achieving students as those for whom they felt the MLE programme was not operating effectively. The greatest concerns were raised by the teacher who had previously taught the class with the lowest-achieving students. Particular concerns were voiced about a group of students within that class who were considered a priority within the school and a target for extra
support.

One reason for the decrease in interaction for low-achieving students may be linked to the teacher aide support that was provided for them. Previously this class of students had sole access to the teacher aide. In the MLE, although support of these students was a priority for the teacher aide, other students were able to access support, approaching the teacher aide for assistance similar to the way they approached the roving teacher. While wider access to the teacher aide might prove beneficial to the operation of the programme as a whole, it may also be detrimental to the amount of teacher aide support received by lower-achieving students. Another consideration, supported by evidence from the teacher interviews, is that the lower-achieving students had more difficulty with the greater self-management expected in the MLE. They were considered by their teachers as more likely to struggle with planning the organisation for their mathematics learning. This perception is supported by Zimmerman’s (1990) suggestion that students in lower achievement tracks tended to lack self-regulatory initiative. Teachers also reported lower-achieving students as being less likely to initiate interaction. This is consistent with the findings of Dukmak (2010) who found that high-achieving boys and girls initiated more interactions than their low-achieving peers.

Types of teacher-student interaction

Groupings for instructional interactions
There was a large decrease in teachers working with small groups, offset by an increase in large group interaction. Given the evidence that suggests students of all ability levels appear to benefit from being taught in small groups (Hattie, 2009), an increase in group size is a possible concern. This assertion is supported in a study by Blatchford, Bassett and Brown (2011) that investigated TSI in relation to class size. They found that the amount of active teaching increased as the size of class increased. They propose that while on the face of it this may seem to students’ advantage, as they are getting more educational input. However they point out that this greater input is at the expense of students’ active engagement, making them more passive in the process of learning. Currently, the use of larger groups, including whole class teaching, is finding some favour in the teaching of mathematics. This is supported by recent research claiming positive benefits of this approach for student achievement (Boaler, 2006, 2008; Hunter, 2005; Hunter & Anthony, 2011). These studies however, tend to advocate that such larger groups be composed of students of a wider range of abilities than the groups in this study. Anthony and Walshaw (2009) when summing up research findings on effectively arranging for learning in mathematics advocate a range of approaches:

When making sense of ideas, students need opportunities to work both independently and collaboratively. At times they need to be able to think and work quietly, away from the demands of the whole class. At times they need to be in pairs or small groups so that they can
share ideas and learn with and from others. And at other times they need to be active participants in purposeful, whole-class discussion, where they have the opportunity to clarify their understanding and be exposed to broader interpretations of the mathematical ideas that are the present focus. (p.9).

Learning within the MLE was not arranged in such a way as to provide opportunities for students across the full range suggested here.

Fluidity of groups in the MLE created organisational challenges for teachers, as well as for some students who no longer had security and predictability as to who would be their teacher, and which group they would be in. But literature on the efficacy of streamed/tracked classes and fixed ability groupings (as these teachers previously used) suggests that a change to more variable groupings is likely to have overall positive outcomes (Boaler, 2009; Rubie-Davies, 2014). Students have been shown to have greater opportunity to learn, higher achievement and greater self-esteem in non-tracked mathematics classes (Boaler, 2008; Boaler & Staples, 2008).

Decrease in organisational interactions
The observational data revealed a decrease in verbal organisational interactions in the MLE. A decrease in verbal organisational interactions seems likely to be a positive change for two reasons. Firstly, it can be argued that less organisational interruptions allows for better continuity within the lesson, which should result in instruction of greater quality. Secondly, the largely verbal organisation that was evident in the single-cell classroom environment may have proved challenging for some students. The substitution of verbal instructions with visual organisational tools, such as individual and class timetables, that occurred in the MLE is likely to have benefited students. Visual organisers allow students to independently access instructions multiple times without needing to refer to a teacher. Although teachers had reservations about this reliance on individual student timetables, the students interviewed seemed positive about their ability to use this tool to organise their learning. It seems likely that students who have difficulty with reading organisational information, such as timetables, may find the expectation that they do not seek verbal organisational support to be challenging. However, this challenge may be moderated by increased access to teacher assistance in the MLE provided by the roving teacher.

Absence of emotionally supportive interactions
Both sets of observations were notable for the lack of emotionally supportive interactions. Observed TSI within the lesson times was overwhelmingly focused on instruction. It seems likely that emotionally supportive interactions did take place, as teachers expressed genuine warmth and caring for their students, and students seemed to genuinely like and feel supported by their teachers. A possible reason for the lack of observed emotional support is the strongly held teacher belief that instructional
sessions were for actively teaching. This focus on instruction became more pronounced in the MLE. As the purpose of a workshop session was to instruct, little priority was given to other types of interaction. This may be detrimental to students who require regular emotional support from their teachers. Emotional support has been shown to be especially important for students who are at risk due to demographic and behavioural factors (Hamre & Pianta, 2005). Hamre and Pianta (2005) found that students who were likely to have difficulty adjusting to the classroom environment, showed no differences in achievement to their peers when placed with emotionally supportive teachers. They describe high emotional support as stemming from teachers’ awareness of and responsiveness to individual student needs.

**Frequency and types of feedback**

In the MLE it seems likely that the decrease in observed feedback was a result of the role of giving feedback having mostly shifted to the roving teacher. Examination of the feedback literature suggests some possible ramifications of this change. Hattie and Timperley (2007) make a distinction between feedback as to whether it is about the task, about the processing of the task or about self-regulation. They identify feedback about self-regulation and feedback about the processing of the task as being most powerful, as they contribute to deep processing and mastery of tasks, Feedback about the task is also described as being powerful when the information is used for improving strategy processing or encouraging self-regulation. Much of the feedback expected of the roving teacher was based on student responses to written follow-up tasks. This coupled with reported time constraints, suggests that the feedback focus was more likely to be on feedback about the task at its most basic level, rather than the more powerful higher level feedback about the task, feedback about self-regulation or feedback about the processing of the task described by Hattie and Timperley.

Tunstall and Gipps (1996) claim that the descriptive Type C and Type D feedback (as outlined in Table 10) are crucial to students’ learning. The formative assessment practices adopted in the MLE appear to exemplify the mastery-orientation of the Type C feedback where teachers acknowledge attainment against specific criteria. With an emphasis on self-management and learner agency in the MLE, one might also expect to see greater use of the learning-oriented Type D feedback. Type D feedback combines strategies described in constructivist approaches to learning, with self-regulating strategies. However, this was not evident in the results. Time constraints and variable knowledge of individual students may compromise the ability of teachers to provide Type D feedback in the MLE.

The third sub-question in this study asked about the perceived changes to TSI and feedback noted by teachers and students. The findings revealed that both were more likely to occur individually and were more frequently student-initiated.
Increased individual teacher-student interaction and feedback

While teachers welcomed the opportunity to interact more often on an individual basis, the more limited student knowledge that teachers brought to these interactions, and the greater number of students with which they might occur needs to be considered. It has been suggested that the quality of an interaction is more important than either its frequency or duration (Alexander, 1995). Therefore the possible replacement of less frequent but higher-quality individual interactions with more frequent but less in-depth individual interactions seems unlikely to be a positive change. In addition it must be noted that the approaches to effective instruction in mathematics outlined by Anthony and Walshaw (2009) do not include individual instruction. In fact teacher perceptions that more individualised instruction is beneficial to students are not generally supported in the research literature (Hattie, 2009).

Student-initiated teacher-student interaction and feedback

Teachers also perceived an increase in instructional interactions initiated by students rather than teachers either through students opting in to appropriate workshops or initiating interaction with the roving teacher. They saw this as a sign of greater learner agency developing in the MLE. While such evidence of self-regulation is considered a desirable trait (Butler & Winne, 1995; Zimmerman, 1990), there is, as previously discussed, a concern around those students who lack these skills. An additional concern is the possible emergence of a gender imbalance, should, as suggested by Dukmak (2010), boys be more likely to initiate interactions than girls.

The final sub-question asked if teachers and students identified changes in the barriers to and enablers of TSI and feedback after moving to the MLE. The changed programme in the MLE saw barriers emerge linked to higher student numbers, while the planning and groupings developed to manage this larger student group were also the source of some new enablers.

Barriers and enablers

Number of students

With 68 students and three teachers in this MLE, the student-teacher ratio of approximately 1:23 was relatively low for the Year 4 level. Schools are funded at a 1:29 ratio for Year 4-8 students (Ministry of Education, 2015i). However, the participants identified student numbers in the MLE as a particular challenge. The suggestion that some students need to build a strong relationship with one teacher is not new to this study. Nor is the concern that larger numbers of students means less is known about each one, which may limit teachers’ ability to connect in emotionally supportive ways (Gerritsen, 2015;
O’Reilly, 2015b). Such criticisms of MLEs tend to be refuted by highlighting the opportunities that they provide for students to build relationships with multiple teachers. It is argued that the traditional classroom where a student only has one teacher for the entire year is unsuitable for some students who may not connect well with that teacher. In the MLE students have the opportunity to make connections with a range of teachers, and greater choice as to the teachers with whom they forge close relationships (Gerritsen, 2015; Lawrence, 2014; M. Wilson, 2015). Perhaps what can be taken from the two sides of this argument, is that the MLE while providing affordances for some students, presents challenges for others.

**Organisational complexity**

Another barrier related to the number of students, was the complexity of organisation required to ensure that students’ individual learning needs were being met. Organisational demands are suggested by Alexander (1995) as one factor that may negate some of the positive impacts of having multiple teachers in a classroom. This barrier may have been somewhat magnified in this particular setting due to the choice of programme adopted by the teachers. By choosing to base instruction for 68 students around the achievement of 16 separate items on a pre-test, the number of possible permutations across the student group was large. While it allowed for highly personalised learning pathways, teachers faced challenges as to how their organisation might cater for these. Teachers saw addressing this challenge as a high priority for them in the MLE.

**Noise and distractions**

There is an assumption that MLEs, due to their greater openness and higher student numbers, will be noisier and more distracting for students (Cook, 2015; Rangiruru School, 2015; L. Wilson, 2015). However, in this study students considered the MLE to be either no more distracting or less distracting than their previous classroom environment. Teachers made no mention of noise and distractions as barriers to TSI in the MLE. Part of the reason for this may be the physical features of the MLE. The floor plan and sliding doors enabled the space to be effectively divided up into smaller spaces for teaching groups, meeting the criteria in the MOE’s MLE assessment tool (Ministry of Education, 2015j). New MLEs like this one are designed in accordance with extensive guidelines developed for acoustics in learning spaces, including doors that provide a high degree of soundproofing (Building Research Association of New Zealand, 2007). The expectations established by this group of teachers in their previous classrooms and then again during the transition to the MLE are also likely to be an important factor in minimising this barrier. Students were observed working in a quiet orderly fashion in all classrooms both before and after the move to the MLE. Other reasons for this potential barrier being minimised in the MLE can be found in the interview data. Higher student engagement coupled with greater student self-management skills were perceived by teachers to be enablers within the MLE. Students perceived that greater access to teachers and more appropriate levels of work through more homogenous groupings minimised distraction as students were more engaged.
Implications

The findings of this study suggest a number of implications for schools planning and preparing for transition to a MLE. While it may be tempting to focus on the very visible physical changes to the learning environment that teachers and students may experience, the changes to teaching practice are of higher priority because it is they that have a noticeable impact on the instructional, organisational and emotional interactions between teacher and student. It appears that the potential impacts will be greater for some students than others. Low-achieving students, students with limited ability to self-regulate, students who lack the skills or disposition to take initiative in their learning, and those who require more emotional support are likely to benefit from greater support in the transition.

Low-achieving students appear to be particularly at risk in the transition process and therefore careful planning and close monitoring of these students would be advisable. Additionally, programmes of learning support need to be managed so that target students receive appropriate levels of support in the MLE. The results of this study suggest a factor that is not considered in the literature promoting greater learner agency particularly in MLEs (Ministry of Education, 2007; Osborne, 2013) - that for some students, the expectation of a high level of learner agency is not necessarily positive or realistic. Skills of self-advocacy, where students are encouraged to initiate interaction with teachers appear to be important in a MLE. Monitoring and support should be considered for those students who for a variety of reasons, may not take initiative to the degree that might be expected in the MLE. Identification of methods to successfully teach and develop these skills would be of value, particularly for those students who have poor self-regulatory skills, as they engage in such a transition. One area that might prove useful in addressing such diverse needs is within the principles of Universal Design for Learning. Universal Design for Learning promotes the provision of multiple means of representation and action (National Center On Universal Design for Learning, 2015). Such an approach may be valuable for teachers wishing to assist diverse learners to successfully access the curriculum and better self-manage their learning within the MLE.

Building strong emotionally supportive relationships was shown in the literature review to be both directly and indirectly linked to enhanced student outcomes, both affective and achievement. Because of this, it is vitally important that teachers transitioning to a MLE consider how these relationships will be maintained. The participants in this study had two terms prior to their transition to build relationships with their home class as well as with other students in the team who came to them for mathematics and reading instruction. The participants believed that this was a contributing factor in students feeling comfortable with all members of the teaching team. In situations where students are new to both the MLE and their teachers, such as at the beginning of a new school year, planning time and opportunities for emotionally supportive interaction would be valuable in establishing positive relationships between teachers and students.
Teachers would benefit from a range of supports both prior to, during and after transition to a MLE. Villa, Thousand and Nevin (2008) believe beneficial outcomes can be achieved in co-teaching situations when importance is placed on systemic supports. Professional development in advance of the move would allow teachers to consider how they might adapt teaching approaches known to be effective to the MLE. Time to plan together may assist in overcoming some of the organisational challenges that arise when attempting to meet the needs of a larger number and diverse range of students. Clarity around learning and assessment is identified as a key component of effective teaching (Absolum, 2006; Hattie, 2009). The challenge in the collaborative teaching structure of the MLE is that this must be a shared clarity. Providing time to plan collaboratively and develop a shared understanding of the learning goals and success criteria appears crucial to teachers being able to give adequate feedback to students in the MLE. Additionally teachers need to consider ways in which they can maximise their use of the more powerful feedback practices in the new environment.

The literature on MLEs and MLPs tends to imply that elements of student centred-learning, such as highly personalised programmes and elements of connectedness, such as learning co-operatively, will quite naturally co-exist in today’s classrooms. The results of this study suggest that in fact teachers need to actively plan for a range of approaches to teaching and learning within the MLE if they are to achieve a balance between the two. In this study, the teachers initial response to setting up the mathematics programme in the MLE allowed for a high degree of student-centredness and personalisation. However, students opportunities to connect with each other and the world beyond the classroom were relatively limited. Therefore, this is another area of challenge faced by teachers in transition to a MLE.

Limitations

The findings of this study must be considered in light of the fact that they represent a snapshot of TSI in a MLE at one point in time. The programme described reflects this group of teachers’ initial solution to a puzzle of practice. At the time of the data gathering, teachers had already identified areas of concern, in particular the realisation that the programme was working effectively for some students and not for others. Therefore, it is to be expected that over time the impacts of the transition on TSI would be somewhat altered as the programme is modified in response to teachers’ evaluation of its efficacy.

The study was located in a very specific context and therefore the results may not be generalisable to other contexts. The participant school was in a high decile urban environment. In addition the school’s student population was particularly culturally homogeneous, with 84% New Zealand European students. The focus was on a Year 4 group, and therefore different results may be found with both younger and older students. The unique features of the student participant group must be also be
considered when reviewing the results. The Year 4 cohort in this school was at a higher level than might be expected when compared to National Standards in mathematics for New Zealand. For the 2014 year almost 75% of students nationally were at or above the National Standard for the end of 3 years at school (Education Counts, 2015). Whereas 88% of the Year 4 group in the participant school were at or above the National Standard on entry to Year 4. In addition, the range of achievement levels in the sample group was skewed slightly higher than Year 4 cohort as a whole, with all participating students at or above the National Standard. Therefore the results may not be generalisable to schools where there is a different student achievement profile. Another limiting factor is that half of the sample group came from one class, and that class represented the lowest-achieving one third of students in the Year 4 group. Additionally four of the five girls in the sample were from that class.

While the MOE’s MLE standard ensures a certain amount of consistency in the physical features of MLEs in New Zealand, individual schools in conjunction with architects are free to interpret those standards in a variety of ways that reflect the school’s needs, priorities and budget. The physical configuration of the MLE in this study displays one interpretation of the standard and therefore may differ to those of other schools in ways that may have had an impact on the results.

The school in this study is an example of the move to a MLE being driven firstly by physical factors - the need to replace unsatisfactory buildings. Therefore, the findings may differ to those that might be obtained in a setting where other drivers, such as a strong belief in MLP, are the initial reason for development of a MLE.

**Future directions**

The differential impacts of the transition to a MLE on different student sub-groups found in this study would be a useful area for further research. In particular, investigation of the effects on low-achieving students would be valuable for teachers seeking to ensure that at-risk students are not further disadvantaged by such a change. It may also be of benefit to examine the provision of learning support for students in MLE settings.

Due to ethical considerations, the study focused only on teacher to student interactions. Given the perceptions that far more interaction was student-initiated in the MLE setting, investigation of both sides of classroom interaction, both teacher to student and student to teacher, may reveal further insights. Additionally only verbal interactions were considered in this study, therefore gathering of data on both verbal and nonverbal interactions may also prove of interest.

As this study only focused on the initial period of change, it would be worthwhile to expand data gathering over a longer period of time. Documenting the journey of teachers and students in transition
through to a point where they are well established in the MLE would be valuable. Further study of the effects of changing learning environments over time may give greater opportunity to reveal the ways in which teachers overcome the challenges of both the change process and those inherent in the MLE itself.

The participant school’s location in a specific socio-economic and cultural context suggests an opportunity for further investigation of MLEs in different school settings, such as provincial and rural areas, or with different or more diverse student populations than the one in this study. Examining the impacts of transition to a MLE with students at other year levels may also be productive. Other comparative work might focus on schools that have arrived at the MLE by a different route, for example as a result of teacher demand for an alternative physical environment which is considered more conducive to particular practices.

This study adds to the literature around co-teaching, in that unlike most of that which exists (Thousand, Villa & Nevin, 2006; York-Barr, Ghere & Sommerness, 2007), it looks at multiple teachers in a regular classroom setting, rather than in special education or second language learning contexts. However, as co-teaching was not the main focus of this study, future investigation of co-teaching practices in the MLE would be extremely worthwhile.

**Conclusion**

Changes to a learning environment have an inevitable effect on the practices of the teachers and experiences of the students within it, either directly through the physical features of the environment, or indirectly as a result of expectations of what might be achieved in that environment. While there is a large and growing body of theoretical literature in support of MLEs and MLPs, this study is one of the few empirical studies to focus on them directly. It highlights a number of practical implications for the increasing numbers of schools making a transition to MLEs. Additionally it suggests a range of areas for further investigation if we are to more comprehensively evaluate the success of the MLE in achieving the valued student outcomes that its proponents believe to be possible.
Appendices
Appendix A – Sample Participant Information Sheet: Teacher

SCHOOL OF CURRICULUM AND PEDAGOGY
Te Kura o te Marautanga me te Ako

TEACHER PARTICIPANT INFORMATION SHEET

Title of Project: Teacher-student interactions in mathematics within a Modern Learning Environment

Student Researcher: Carolyn Crow  University Supervisor: Dr Mei Lai

I am a teacher and Deputy Principal at Sherwood Primary School, currently on leave as a Lead Teacher Masters Scholar with the Woolf Fisher Research Centre. The Woolf Fisher Research Centre is a University of Auckland research centre for the development of education and schooling success. The research will form the basis for my Master of Education thesis, under the supervision of Dr Mei Lai. The project will be completed within the 2015 school year.

I would like to invite you to participate in a research project to investigate the interaction between teachers and students in mathematics, comparing this in a traditional classroom setting and in a Modern Learning Environment.

The research project is designed to compare teacher-student interactions in mathematics in the two different learning environments through researcher observation, the use of a student questionnaire and interview to help understand the students’ perspectives, and an interview with teachers to provide data on the teachers’ perspectives.

I would like to collect information from the participating teachers and a group of their students on two occasions during the research period, firstly in June and again in September. On each occasion, the information will be collected in the following way:

- I will observe each teacher’s maths class and make observation notes. This will be done in such a way that ensures there is no disruption to the lesson. A second recorder, who has signed a confidentiality agreement, will be involved in the observation sessions solely for the purpose of checking the accuracy of the researcher’s notes against what was said.

- Following the observations of mathematics sessions, each child in the student participant group will complete a brief paper-based questionnaire. The questionnaire will take approximately ten minutes to complete. To ensure that the ability to read the questionnaire is not a barrier to any student participant it will be read to them.
Following the questionnaires, the students will take part in a short face-to-face interview. The focus of this interview will be to find out the reasons behind some of their questionnaire responses. Interviews will be recorded solely for the purpose of checking the accuracy of the interviewer’s notes against what was said. The interview will take between ten and fifteen minutes and will be conducted at a time and place that will minimise any possible interruption to the students’ formal learning.

To gather information about teachers’ perceptions of their interactions with students within the two different classroom environments, I would like to meet with you on two occasions, firstly in June and then again in September. The interview will take between fifteen to twenty minutes of your time and will be conducted at a time and place that is convenient for you. Interviews will be recorded solely for the purpose of checking the accuracy of the interviewer’s notes against what was said. You will be given a transcript of the recording and will have two weeks from that time to clarify any of your answers.

Should you agree to participate in this research, I request that you sign the attached consent form and return it in the envelope available to the school office. If you consent then I will contact you to arrange a suitable time for the observations and the interview.

Participation in this research project is voluntary. Your school has also agreed that your participation is voluntary and that your participation, or non-participation, will not influence your relationship with the school, your employment status, or access to school services. You can withdraw from participating at any time without having to give any reason for your withdrawal; your decision will be completely respected and no further questions will be asked. You can withdraw any information at any time until the data has been analysed, which will take place by 1st July 2015.

Participation in this research is voluntary for students, and they don’t have to be involved. Bayfield School agrees that their participation is voluntary and whether they do or don’t participate doesn’t affect anything else at school. Students can withdraw from participating at any time. They can also withdraw any information that they have provided at any time up until it has been analysed. This would be 1st July 2015. Neither they, nor their parent/caregiver needs to give any reason for their withdrawal as their decision will be completely respected.

All data stored digitally (including questionnaires, interviews and student achievement data) will be kept on a password-protected computer for a period of six years, after which the data will be deleted. All paper data will be kept in a locked cabinet at the Woolf Fisher Research Centre for a period of six years after which it will be destroyed by shredding. All consent forms will be kept separately from the data.

Reports, articles and feedback arising from this research will not identify the school as the source of the data. No information obtained in the course of this research will be used for purposes other than that stated e.g. for appraisal.

Overall results of the research will be made available to your school. Participants will not be named, but within the school, participants may know one another. Results may also be published in journal publications, or presented in education conferences.

If you consent to participating in this project, please complete and sign the attached consent form and return it in the envelope provided to the labelled box in the school office.

Thank you very much for your time and help in making this project possible. I am available to answer any queries you may have. If you have any queries or wish to know more, please phone or email any of us at the addresses below:
Mrs Carolyn Crow  
email: ccro459@aucklanduni.ac.nz

Dr. Mei Lai  
Senior Lecturer  
Faculty of Education  
The University of Auckland  
Email: mei.lai@auckland.ac.nz  
Ph: (09) 373 7599 ext 48658

The Head of School is:  
Dr. Helen Hedges  
School of Curriculum and Pedagogy  
Faculty of Education  
The University of Auckland  
Ph: (09) 373 7599 ext 48606  
email: h.hedges@auckland.ac.nz

For any concerns regarding ethical issues you may contact:

The Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland Research Office, Private Bag 92019 Auckland 1142  
Ph: (09) 373 7599 ext. 83711 email: humanethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE  
ON 26 April 2015 for (3) years, Reference Number 014075
Appendix B – Sample Consent Form: Teacher

SCHOOL OF CURRICULUM AND PEDAGOGY
Te Kura o te Marautanga me te Ako

TEACHER CONSENT FORM

THIS FORM WILL BE HELD FOR A PERIOD OF SIX YEARS

Title of Project:  Teacher-student interactions in mathematics within a Modern Learning Environment


I agree to participate in this research.

I have read the Participant Information Sheet and I understand the research and why I have been selected. I have had the opportunity to ask questions and to have them answered to my satisfaction.

I understand that I may withdraw myself from this project at any time, without having to give any reasons.

I understand that I may withdraw any information I have provided at any time up until 1st July 2015, without having to give any reasons.

I understand that my participation is voluntary and that my school has agreed that my participation or non-participation will not influence my relationship with the school, my employment status, or access to school services.

I understand that Mrs Carolyn Crow will observe in my maths class. I understand that a second recorder, who has signed a confidentiality agreement, will be involved in the observation sessions solely for the purpose of checking the accuracy of the researcher’s notes against what was said.

I agree to take part in short face-to-face interviews with Mrs Carolyn Crow twice during the year.

I agree that the interviews may be recorded for the purpose of checking the accuracy of the interviewer’s notes against what was said.

I understand that I will be given a transcript of the recording and will have two weeks from that date to clarify any of my answers.
I understand that students in my class will be invited to participate in this research.

I understand that my confidentiality and privacy will be protected at all times, and that neither my name, nor the names of the students or the school will be identified in any publication that arises from the research.

I understand that the data will be stored separately from the consent forms on a password-protected computer and/or in a locked filing cabinet and will be destroyed after a period of six years.

Name: __________________________________________________

Signature: _______________________________________________ Date: ____________

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 26 April 2015 for (3) years, Reference Number 014075
Appendix C – Teacher Observation Schedule

Interaction Audience Observation Schedule

<table>
<thead>
<tr>
<th>Date:</th>
<th>Teacher:</th>
<th>Start Time:</th>
</tr>
</thead>
</table>

Main group size interacted with in each 1 minute period

<table>
<thead>
<tr>
<th>Coding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>No verbal interaction with student/s</td>
</tr>
<tr>
<td>I</td>
<td>Individual verbal interaction with one student</td>
</tr>
<tr>
<td>R</td>
<td>Roving - interacting with individual and groups</td>
</tr>
<tr>
<td>S</td>
<td>Small group verbal interaction with group of 2-8 students</td>
</tr>
<tr>
<td>L</td>
<td>Large group verbal interaction with a group of 9-20 students</td>
</tr>
<tr>
<td>W</td>
<td>Whole class verbal interaction with a group of 21 or more students</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME</th>
<th>CODING</th>
<th>GROUP DETAILS</th>
<th>FIELD NOTES (Descriptive)</th>
<th>FIELD NOTES (Reflective)</th>
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<td>25</td>
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<td>26</td>
<td>N</td>
<td>I</td>
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<td>L</td>
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<td>27</td>
<td>N</td>
<td>I</td>
<td>S</td>
<td>L</td>
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<td>28</td>
<td>N</td>
<td>I</td>
<td>S</td>
<td>L</td>
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<tr>
<td>29</td>
<td>N</td>
<td>I</td>
<td>S</td>
<td>L</td>
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<tr>
<td>30</td>
<td>N</td>
<td>I</td>
<td>S</td>
<td>L</td>
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<table>
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<th>S</th>
<th>L</th>
<th>W</th>
<th>R</th>
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Appendix D – Teacher Interview: Indicative Questions Time 1

Teacher Interview Time 1

As you know, this study is looking at the interactions between teachers and students during maths times.

Firstly, I’d like you to tell me a bit about the different ways that you interact with students in your maths class. What are the purposes of these interactions? Are there any kinds of interaction with your students that you would like to have more of? To have less of?

Next I’d like you to consider how often you get to work with your students. Thinking about maths times over a typical week, roughly how often do you get to interact with each student individually? In a group setting?

Now if you could think about the amount of time you have to interact with students

• In terms of time, how long might you spend with each student individually? Groups of students?
  • How do you feel about the amount of time you have to interact with students?
  • Are there any things that already help you to maximise your time with your students?
  • Are there any additional things that you think might help you to have more time with students?

Finally I’d like to ask a few questions about feedback to students.

What methods do you use to give feedback to students in maths?

For example -

• How do you let students know when they have been successful?
• How do you find out about students’ learning needs?
• How do you set student goals? How do you let students know about their next steps?

Which methods of feedback do you think you use most often? Why?
Appendix E – Teacher Interview: Indicative Questions Time 2

Teacher Interview Time 2

This time I’d like to ask you a few questions about the way you now work with your students in maths times. In this new environment what has changed and why, what has stayed the same and why, and finally how you feel about the way things are going.

So previously you each had a maths class that was a group of students at similar numeracy stage and you worked with that same group each day. I saw last week that you have moved to a different way of grouping the students for instruction. Can you tell me a bit about that and the thinking behind it?

What has the impact of this new way of working on the instructional interactions with the students? Good points? Challenges?

How about giving feedback as to how they are going - do you think this is or will be easier or more challenging in the new structure?

What about the emotional supports - when you have changing groups all the time, what impact do you think that will have on the way you give students those little bits of teacher interaction that help them emotionally? The relationships you have with them.

What about organisational interactions you have with them - I saw the whole group gathered together at the start and end. Is that how you see it working in ensuring the organisation is clear?

I noticed you have a timetable on the board for each teacher as well as the individual student timetables - do you find you have to do much verbal organisational interaction with the students to back this up?

(Additional questions on barriers and enablers from Time 1 interview)

Finally, if we could come back to the overall question I’m looking at - what has the impact been of the change to the MLE on the interactions between yourself/the other teachers and your students in maths times? Things that have been positive - things that have been not so positive - things that you’re not sure about yet.

So if you had to choose one thing that stands out for you as a drawback of the move to the MLE what would it be? And one thing that is a real positive?
Maths Talk

Student Questionnaire
**Maths Talk**

**Student Questionnaire**

**Directions**

I am going to read some sentences about different ways a student might feel about his or her teacher and the work that they do in their maths times. All the answers you give are completely confidential. That means that your teacher will not see them or know how you have answered.

As I read the sentences, think about your teacher and maths times in your class. We would like to know how you feel about the way your teacher works with you in maths times. After I read the sentence, I would like you to tell me how often you feel this way.

To answer please circle one word below the sentence that says how often you feel or think that way. Think about if you always feel or think that way or if you never feel or think that way. Please try to answer right away, as we want to know your first thoughts when you hear the sentence.

I will read each sentence twice for you.

1. **My teacher talks to me in ways that make me feel that I can do well in maths.**

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

2. **I get rewarded by my teacher for doing well in maths.**

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

3. **My teacher and I agree about the things I am good at in maths.**

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

4. **My teacher asks me to share my ideas and answer questions in maths times.**

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

5. **My teacher talks to me about the things that I have done correctly in maths.**

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>
6. My teacher and I talk about what I need to work on next in maths.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

7. My teacher clearly explains how I am expected to do my work in maths times.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

8. My teacher tells me when I have done well in maths time.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

9. My teacher and I talk about what I need to do to improve in maths.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

10. My teacher talks to me in ways that make me feel happy about doing maths.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

11. My teacher tells me when she thinks I have made a good effort in maths times.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

12. My teacher tells me when I have not done well in maths time.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

13. My teacher and I agree about the things that I find hard in maths.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

14. My teacher clearly explains what I need to do during maths times.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>
15. I get punished by my teacher if I don’t do well in maths

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

16. My teacher spends time explaining ideas to me in my maths class.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

17. My teacher talks to me about how to make my maths work correct.

<table>
<thead>
<tr>
<th>Never</th>
<th>Hardly ever</th>
<th>Sometimes</th>
<th>Lots</th>
<th>Always</th>
</tr>
</thead>
</table>

18. Is there anything else you would like to share about the way your teacher works with you during maths classes?

If so write it down below.

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

Thank you for doing this questionnaire.
Appendix G – Student Interview: Indicative Questions Time 1

**Student Interview Time 1**

As you know, I’m asking teachers and students about their maths class times. I’d like you to think about your maths classes this term and think about the ways that your teacher talks to you that help you learn in maths.

What kinds of things does your teacher talk to you about that help you learn when you are working in a group?

What kinds of things does your teacher talk to you about that help you learn when you are working on your own?

What kinds of things does your teacher do that let you know how well you are going with your maths?

Prompts -

• How do you know when you have something correct or if you have done something wrong?
• How do you find out what to do if you get stuck on a maths problem?
• How does your teacher know what you already know?
• How does your teacher know what you might need to learn next?
• How do you know what your goals are in maths?

Are there any things that make it hard for you to work with your teacher in maths classes?

Are there any things that make it easier for you to work with your teacher in maths classes?

Do you think you get to spend enough time talking with your teacher in maths? Why/why not?

(Any questions generated by student questionnaire response, particularly open-ended response for Question 18)
Appendix H – Student Interview: Indicative Questions Time 2

Student Interview Time 2

Your learning space is very different from the classroom you were in when I last came in. I’d like to ask you some questions about what it’s like in that new space. I’d also like to find out if you notice any differences between the way you work with your teachers now to when you were in your old classroom.

So tell me about your maths times in this new space. Think about maths times over the last week - what are they like?

The things that help you know what you’re meant to be doing
The things your teacher talks to you about that help you learn
The things that help you if you get stuck in maths
The things that help you know how well you are going with your learning
The things that help you know what your goals are in maths
The amount of time you get with a teacher

Are any of these things really different to what you used to do?
Which are good differences and why? Which differences are not so good and why?

(Individual student follow-up questions developed from Interview 1 and/or Questionnaire 2)


