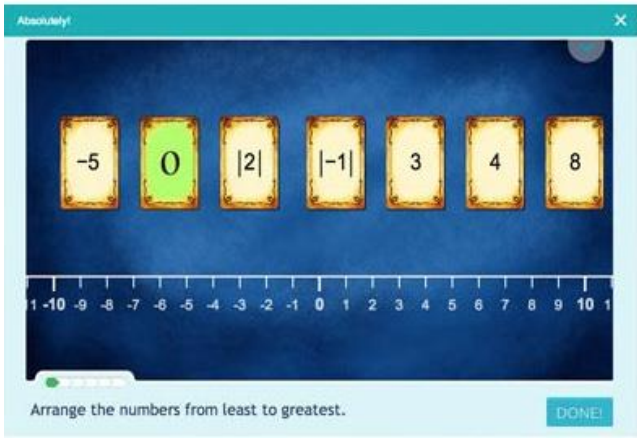
RESEARCH EVALUATION:

MATIFIC MATHEMATICS LEARNING RESOURCES



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matific

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The Centre for Educational Research

RESEARCH EVALUATION OF MATIFIC MATHEMATICS LEARNING RESOURCES

PROJECT REPORT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

LIST OF ACRONYMS

FEM: Framework for Engagement with Mathematics

ICSEA: Index of Community Socio-Economical Advantage

IWB: Interactive Whiteboard

LOTE: Languages other than English

NAPLAN: National Assessment Program: Literacy and Numeracy

PCK: Pedagogical Content Knowledge

TPACK: Technological Pedagogical Content Knowledge

ZPD: Zone of Proximal Development

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I thank John Ley for his important contribution as part of the research team and his assistance in compiling this research report. This project would not have been successful without the cooperation of the school principals from the eight schools, as well as the commitment of the 16 participating teachers and their students. I acknowledge the students who participated in the focus group discussions at each school; their generosity in sharing their thoughts is appreciated.

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Catherine Attard

EXECUTIVE SUMMARY

Background

Declining student engagement with mathematics is a major concern for educators and other stakeholders in education. Many people attribute disengagement from mathematics to negative experiences during the school years. These experiences often stem from a lack of curriculum relevance to students' everyday lives and the traditional classroom practices emphasising drill and practice, and rote learning. Decreased engagement can have a negative impact on students' future opportunities in relation to their ability to make important decisions in everyday life and their ability to access tertiary education and careers requiring high levels of mathematics (Attard, 2013).

The need to incorporate digital technologies into the teaching and learning of mathematics is now an integral aspect of Australian classrooms, with current curriculum documents expressing explicit expectations that digital technologies are incorporated into the teaching and learning of mathematics (Australian Curriculum and Reporting Authority, 2012; Board of Studies New South Wales, 2012). Although there are arguments that suggest the use of digital technologies has potential to transform education (Levin & Wadmany, 2008), to date there has been little research exploring the effectiveness of digital technologies in enhancing student learning and their engagement with mathematics, particularly in the primary classroom (Shin et al., 2012). The types of digital technologies and their affordances may also influence whether or not there is an impact on student learning and engagement.

Given that almost all young people are actively involved in game playing in either a concrete or digital form, it makes sense to expect that the use of digital games in education could assist in increasing student engagement with content such as mathematics, that may otherwise feel irrelevant to students' everyday lives. The use of digital games could also assist in bridging the digital divide between how ICT is used at home and at school, as described by Selwyn, Potter, and Cranmer (2009).

Matific is a range of digital mathematics resources that aim to improve mathematics outcomes through the use of game-based applications. Each application, referred to as an episode, focuses on a specific mathematical concept. Each concept is linked to the mathematics curriculum and presents a series of five questions that provide a gradual increase in challenge.

The Project

The purpose of this research evaluation was to investigate whether and how the use of Matific resources, used within a range of Australian primary school classrooms, can improve student engagement with mathematics and assist students in learning and understanding challenging mathematical concepts.

Methods

The research aimed to address the following questions:

1. To what degree do the Matific digital mathematics resources assist primary children to understand and learn difficult mathematics content?

2. In what ways do the Matific digital resources influence student engagement with mathematics?

This research utilised case study methodology. Eight primary schools from a range of socio-economic areas were selected, invited and agreed to participate in the project. None of the schools had used Matific prior to their participation in this project. Each of the schools was unique in relation to geographical location, academic performance, student population and cultural makeup. The schools also had differences in the number and amount of access they had to digital devices. Two teachers and their students from each school were invited to participate. It was a requirement that the teachers be working in the same grade or stage. Students and teachers from Grades 1 to 6 participated in the study.

On commencement of the study either one or both researchers spent one day working with the participating teachers at each school. They were provided with an orientation of the Matific resources and were supported in developing a pre-test once they had selected a topic. The teachers then collaboratively planned a unit of work that incorporated Matific episodes. Five to six students from each class group participated in a focus group discussion to gauge their engagement with mathematics, their perceptions of mathematics teaching and learning, and their views and experiences of using technology during mathematics lessons.

During the second stage of the study the teachers implemented the unit and students completed a post-test on its conclusion. The researcher/s returned to the school and conducted individual interviews with each participating teacher to discuss their reactions to using Matific. Student focus group discussions were also held to investigate changes in students' perceptions as a result of using Matific. The various units of work were finalised and are published as an appendix to the full report along with copies of the pre- and post-tests.

Project Findings

Teachers' Perceptions of Matific

The 16 participating teachers in this study used the Matific resources in a variety of different ways. This resulted in a diversity of opinions about the resources and varying levels of success in terms of student achievement and engagement.

Differentiated Learning

A Matific affordance that appeared regularly in the data is the ability for teachers to individualise learning by assigning different tasks to different students. When teachers did

differentiate the learning, students appeared to be more engaged because the episodes contained an appropriate level of challenge.

Some of the teachers who allocated all tasks to all students did so to provide choice for their students. Other teachers assumed students would complete as many episodes as they could, and the results of this on student engagement were not so positive.

Matific at Home and School

The teachers who did set Matific as homework found it to be successful and highly engaging for their students, although there were, as would be expected, some students who did not have access to either the internet or a device. In one school this was addressed by allowing access to the school's computers before school and during breaks. Despite not setting Matific for homework, several of the teachers found that their students used Matific at home because they found it so engaging.

Student Voice

Many of the discussions around the use of Matific related to either an alignment with or a mismatch between teachers' intentions, beliefs and knowledge of their students, their students' experiences of Matific, their beliefs about learning, and their abilities. For example, the teachers at one school used all the data they had available to ensure students were allocated appropriately levelled Matific episodes and they promoted discussion with and amongst students. They adjusted and adapted their teaching and students' learning experiences according to their students' reactions to the resources. Conversely, in classrooms where students were not provided with reflection opportunities, the teachers appeared to be unaware of what their students thought about using the Matific resources and whether their students felt the resources were assisting them to learn. This was evident in more than one of the schools in this project.

Integration into Teaching Practice

A significant variable across the case studies was the way the teachers integrated the Matific resources into their teaching practices. Those teachers who enthusiastically took advantage of all of Matific's functionality appeared to have made more significant changes to their practices when compared to those who did not. The teachers who only accessed a minimum of Matific's affordances really did not adapt their practices. Rather, Matific appeared to be an 'add-on' to existing teaching and learning activities.

All of the teachers in the project stated that would be willing to continue the use of Matific and spoke favourably about Matific in comparison to other digital resources they had used in the past.

Learning from Matific

One of the most significant outcomes emerging from the qualitative data gathered from students is that Matific assisted learning. Students from across all eight case studies talked about how the Matific episodes helped them learn mathematics and were able to talk about the mathematics they had learned, rather than focusing on the actual game-related aspects of the episodes.

Size and Structure of Matific Episodes

The size and structure of the Matific episodes was one factor that contributed to student learning. The students were able to focus on very specific mathematical concepts and skills, and this focus was able to be maintained because each episode consisted of only five questions. The students also noted that they were unable to 'cheat' when repeating episodes as the questions were different with each attempt.

Scaffolding Learning

The element of Matific that was most commonly attributed to assisting students' learning was the careful scaffolding built into each of the episodes. The assistance provided when answers were incorrect helped the students to build an understanding of the mathematical concepts while also building their confidence.

Pre- and Post-Test Data

The quantitative data gathered from pre- and post-tests indicate that the overall Improvement Index for all schools is 34%. This means that students on an average improved by 34% of the available marks. This confirms and aligns with students' perceptions that learning took place, however it is not possible to claim whether or how much the use of Matific influenced this outcome as students would be expected to show some growth when exposed to teaching, regardless of what resources are used.

Engagement and Matific

It is clear from the data gathered from students and their teachers that engagement with mathematics improved as a result of using Matific. It is important to acknowledge that the majority of teachers in this project had not regularly used digital technologies in their teaching of mathematics, so the sudden introduction of a resource such as Matific would have had a novelty effect on the students involved and this would have had some influence on their engagement.

Feedback and Rewards

An important point of difference between Matific and other digital resources the participating students had used in the past was the fact that rather than simply state when an answer was incorrect, Matific provided assistance that promoted the development of conceptual understanding. This was an outstanding feature that students felt was beneficial to their engagement and their learning. Tied in with the instant feedback provided by Matific was its reward system. This feature was considered to be extremely engaging for

almost all of the focus group students across the eight schools. The most significant benefit of the reward system was that it provided intrinsic motivation for students to continue working hard. The simple 'super awesome' statement promoted perseverance amongst almost all of the students, a characteristic that is important in mathematics learning, particularly in the area of problem solving.

Matific is Fun

An outstanding feature of the Matific resources, according to the students, is that it is fun to use. The change from seeing mathematics as something to be tolerated or endured to something that is fun indicates that there was high affective engagement. It should be noted that the word 'fun' did not simply equate to the game aspect of the resources. Rather, the data indicate that the students found it was fun because they felt they were learning.

Challenges

Minor challenges were experienced by some of the teachers and students in this study:

- None of the schools in this study had access to a 1:1 device program.
- Several of the teachers in this study found it was difficult to use Matific on an iPad, but this was because the actual iPad app had not been downloaded and it was a challenge to get apps downloaded in a timely manner.
- Some teachers did not feel comfortable setting Matific episodes for homework because they were aware that not all students had access to the internet or to computers or tablets.

Recommendations

1: Development of 'just in time' professional learning resources

This project revealed a vast range of technological pedagogical content knowledge (TPACK) amongst the participating teachers. Their ability to incorporate the Matific resources varied, regardless of their depth of teaching experience. This related to different factors that included a lack of confidence in using the technology itself, a lack of knowledge in relation to integrating the technology into teaching practice, and limited knowledge in how the data generated by students' use of Matific could be used to inform practice. One-off, face-to-face professional development may not be the solution to this issue. Rather, it is suggested that Matific invest funds to develop a series of online professional learning videos that provide professional learning material to develop teachers' TPACK (not specifically related to using Matific resources). This material should be evidenced based. That is, it should have a foundation of educational theory and best practice. Short video snippets would provide 'just in time' learning for teachers and should include strong justification for suggested practices.

2. Provision of exemplars for using Matific when 1:1 devices are not available.

It is realistic to expect that few schools have access to one device per student. For example, having group activities where a group of students works on Matific for part of the lesson

before handing over devices to other students. Matific homework is another issue – teachers can provide alternate homework tasks to provide choice. Those without internet or computers at home could also be given the option to access school computers in the library and other settings out of school hours. These various scenarios can be detailed on the Matific website.

3. Designing an alternate structure for gathering student data

This recommendation directly links to Recommendation 2. When schools do not have access to 1:1 devices, an alternate system within Matific for recording group scores or for allocating students to groups, and tasks to groups would be beneficial. This would be of great benefit to the many teachers and students who do not have 1:1 access. Sharing devices can be beneficial to learning, as it promotes mathematical discussion and reasoning.

4. Embedding reflection prompts and linking the proficiencies/Working Mathematically into Matific episodes

It is strongly recommended that Matific include examples of reflection prompts that link to individual or groups of episodes. This would encourage teachers to consider Matific as more than an exercise in fluency, and would promote the Proficiencies/Working Mathematically components to enrich student learning and address a broader range of curriculum requirements.

5. Promote the use of Matific as a valuable source of assessment data

Many teachers still depend on pen and paper testing in mathematics yet if all aspects of Matific are used, valuable formative and/or summative assessment data are generated. A reminder of this within the Matific website, perhaps alongside reflection prompts would be beneficial in promoting Matific as something more valuable than fluency building.

6. Further integration of Proficiencies/Working Mathematically

Working Mathematically/Proficiencies integration needs to feature more prominently on the Matific website. Teachers need to be reminded that this should be embedded in all lessons, and understanding how to ensure Working Mathematically features in lessons that integrate Matific would make the resources more attractive to teachers and make mathematics lessons more valuable for students.

7. Further research

This study was limited in terms of the number of schools involved, the duration of the study, and the exclusion of a control or wait group. To gain a deeper understanding of the potential of Matific resources to improve mathematics learning and to gauge whether student engagement would eventually wane once the novelty of a new resource has worn off, it is recommended that a longitudinal study be conducted. This study should include a control or wait group, and should also incorporate data from caregivers to explore whether Matific could improve mathematics learning beyond the school classroom.

INTRODUCTION

Matific is a range of digital mathematics resources that aim to improve mathematics outcomes through the use of game-based applications. Each application, referred to as an episode, focuses on a specific mathematical concept. Each concept is linked to the mathematics curriculum and presents a series of five questions that provide a gradual increase in challenge.

The Matific suite of resources offers hundreds of episodes for primary school students and provides a range of affordances for classroom teachers. Teachers are able to assign specific tasks to individual students to complete in class and for homework. They are able to track each student's results and they have the ability to allow parents/caregivers access to their child's progress. Matific episodes link to the appropriate curriculum documents and link to other commonly used frameworks such as the NSW Numeracy Continuum and some commonly used mathematics textbooks.

The purpose of this research evaluation was to investigate whether and how the use of Matific resources, used within a range of Australian primary school classrooms, can improve student engagement with mathematics and assist students in learning and understanding challenging mathematical concepts. The following section provides a brief contextual background to the study.

Engagement and Mathematics

Declining student engagement with mathematics is a major concern for educators and other stakeholders in education. Many people attribute disengagement from mathematics to negative experiences during the school years. These experiences often stem from a lack of curriculum relevance to students' everyday lives and the traditional classroom practices emphasising drill and practice, and rote learning. Decreased engagement can have a negative impact on students' future opportunities in relation to their ability to make important decisions in everyday life and their ability to access tertiary education and careers requiring high levels of mathematics (Attard, 2013).

Fredricks, Blumenfeld and Paris (2004) define engagement as a deeper student relationship with classroom work that is multi-faceted and operating at operative, cognitive and affective levels. Operative engagement involves the idea of active participation and involvement in academic and social activities, and is considered crucial for the achievement of positive academic outcomes. Affective engagement involves students' reactions to school, teachers, and peers influencing their willingness to get involved in schoolwork. Cognitive engagement involves investment, recognition of the value of learning, and a willingness to go beyond the minimum requirements (Attard, 2014; Fair Go Team NSW Department of Education and Training, 2006; Munns & Martin, 2005).

For the purpose of this report the term engagement will refer to engagement with mathematics that encompasses operative, cognitive and affective dimensions, leading to students valuing and enjoying school mathematics and seeing connections between school mathematics and their own lives. In this definition engagement includes individual thoughts that are projected outwards in terms of a person's investment and effort towards learning, as well as those relational behaviours that occur within the mathematics classroom (Attard, 2013). This definition forms the theoretical foundation for the Framework for Engagement with Mathematics (FEM) (Figure 1), introduced by Attard (2014) as a tool devised to assist teachers in planning engaging learning experiences in mathematics. The FEM is used in this report as a lens to assist in determining whether the Matific resources were successful in increasing students' engagement with mathematics.

FRAMEWORK FOR ENGAGEMENT WITH MATHEMATICS

In an engaging mathematics classroom, positive pedagogical relationships exist where:

- students' **backgrounds** and pre-existing knowledge are acknowledged and contribute to the learning of others;
- the teacher is **aware** of each student's mathematical abilities and learning needs;
- **interaction** amongst students and between teacher and students is continuous;
- the teacher models **enthusiasm** and an enjoyment of mathematics and has a strong **pedagogical content knowledge; and**
- **feedback** to students is constructive, purposeful and timely.

In an engaging mathematics classroom, engaging pedagogical repertoires mean:

- there is **substantive conversation** about mathematical concepts and their applications to life;
- tasks are positive, provide opportunity for all students to achieve a level of **success** and are **challenging** for all;
- students are provided an element of **choice;**
- technology is embedded and used to enhance mathematical understanding through a **student-centred** approach to learning;
- the **relevance** of the mathematics curriculum is explicitly linked to students' lives outside the classroom and empowers students with the capacity to transform and reform their lives; and
- mathematics lessons regularly include a **variety** of tasks that cater to the diverse needs of learners.

Students are engaged with mathematics when:

- mathematics is a subject they enjoy learning;
- they value mathematics learning and see its relevance in their current and future lives; and
- they see connections between the mathematics learnt at school and the mathematics used beyond the classroom.

Figure 1: Framework for Engagement with Mathematics

Digital Technology, Mathematics and Student Engagement

There are arguments that the traditional classroom practices that have largely consisted of print-based resources are no longer able to meet the needs of contemporary learners of mathematics because of the limited forms of representation.

> *Materials with multiple representations, various difficulty levels of learning tasks and different levels of support are necessary to appeal to the abilities, interests and needs of individual learners (Rose, Meyer, & Hitchcock, 2005, as cited in Shin, Sutherland, Norris, & Soloway, 2011, p.542).*

The need to integrate digital technologies into the teaching and learning of mathematics is now an integral aspect of Australian classrooms, with current curriculum documents expressing explicit expectations that digital technologies are incorporated into the teaching and learning of mathematics (Australian Curriculum and Reporting Authority, 2012; Board of Studies New South Wales, 2012). Literature around digital technologies and mathematics suggest the implementation of new technologies has potentially changed teaching and learning radically, providing opportunities for a shift of focus from the mechanics of action to a more problem-solving based approach. This notion is supported by Yelland and Kilderry (2010), who claim the traditional view of mathematics that was focused on memorisation and rote learning is now replaced with a view of mathematics that has purpose and application.

Although there are arguments that suggest the use of digital technologies has potential to transform education (Levin & Wadmany, 2008), to date there has been little research exploring the effectiveness of digital technologies in enhancing student learning and their engagement with mathematics, particularly in the primary classroom (Shin et al., 2012). The types of digital technologies and their affordances may also influence whether or not there is an impact on student learning and engagement.

In previous studies by Attard and Curry (2012) and Attard (2015), mathematics lessons that incorporated technologies that required students to act as consumers rather than producers, that is, the students simply played a game or responded to mathematical questions similar to what would be found in a text-book or worksheet, were less successful than lessons that required students to produce digital artefacts that illustrated mathematical thinking. However, there is emerging research into digital game-based learning that suggests that some digital games can and do improve student engagement and learning (Shin et al., 2012).

Gamification and mathematics

Given that almost all young people are actively involved in game playing in either a concrete or digital form, it makes sense to expect that the use of digital games in education could assist in increasing student engagement with content such as mathematics, that may otherwise feel irrelevant to students' everyday lives. The use of digital games could also

assist in bridging the digital divide between how ICT is used at home and at school, as described by Selwyn, Potter and Cranmer (2009).

The terms 'game based learning' (GBL) and 'gamification' have begun to appear regularly in academic literature. GBL, defined as the use of video games for educational purposes (Kingsley & Grabner-Hagen, 2015), has been shown in some research to enhance motivation towards learning and academic performance. One concept stemming from GBL is gamification, which as Goehle and Wagaman suggest, is a natural fit for education (2016). Interestingly, there are several interpretations of the definition of gamification, which is generally suggested to be the use of game design elements within a non-game context (Brigham, 2015). A teacher might gamify an activity or the teaching of a particular concept by adding achievement badges, rewards and levels in an attempt to increase student engagement (Goehle & Wagaman, 2016; Kingsley & Grabner-Hagen, 2015). The purpose of gamification within education is the use of game elements such as rewards and game-like activities to promote learning and engage and motivate students. In the context of this definition, the Matific resources could be considered as gamification of mathematics learning.

THE PROJECT

The aim of this research evaluation was to investigate the effectiveness of the Matific suite of digital mathematics resources in the primary mathematics classroom in improving student learning and enhancing students' engagement with mathematics.

The research aimed to address the following questions:

1. To what degree do the Matific digital mathematics resources assist primary children to understand and learn difficult mathematics content?

2. In what ways do the Matific digital resources influence student engagement with mathematics?

Research Design and Methods

This research utilised case study methodology. Eight primary schools from a range of socio-economic areas were selected, invited and agreed to participate in the project. None of the schools had used Matific prior to their participation in this project. Each of the schools was unique in relation to geographical location, academic performance, student population and cultural makeup as detailed in Table 1. The schools also had differences in the amount of access they had to digital devices.

School and Grades	Type/Location	(ICSEA*) Average 1000	Technology	NAPLAN performance year 5 Numeracy All 493	LOTE **	No. Students	Indigenous Students
A	Government K-6 Metropolitan	1186	Computer lab with desktops Few ipads	619 Substantially above	73%	1085	0%
B	Government K-6 Semi-rural	953	Computer lab with desktops Few ipads	463 below	48%	308	5%
C	Systemic Catholic School K-6 Regional	1026	Computer lab with desktops	507 Close to	5%	130	5%
D	Government K-6 Metropolitan	996	IWB, desktops, laptops and iPads	506 above	81%	811	2%
E	Systemic Catholic School K-10 Regional	1020	Computer lab with desktops	506 above	3%	429	6%
F	Systemic Catholic School K-6 Regional	1023	Computer lab with desktops A few iPads	476 below	41%	152	2%
G	Government K-6 Metropolitan	946	Computer lab with desktops Few iPads	498 above	75%	383	3%
H	Government K-6 Metropolitan	1159	Computer lab with desktops Few iPads	590 Substantially above	85%	693	0%

Table 1: Research Sites

Two teachers and their students from each school were invited to participate. It was a requirement that the teachers be working in the same grade or stage. Kindergarten was excluded for inclusion in this project due to the difficulty in gaining quality data from student interviews.

A participatory action research approach was employed as a way for the teachers to work in partnership with the researchers and to assist the teachers in integrating the Matific resources. The research team consisted of one academic and a research assistant, both of whom have expertise in mathematics education. In addition to collecting data from interviews, focus groups, pre-and post-tests and unit documentation, the research team assisted the teachers in identifying topics, designing pre- and post-tests and provided an orientation of the Matific resources including the tools available for teachers.

On commencement of the study either one or both researchers spent one day working with the participating teachers at each school. They were provided with an orientation of the Matific resources and were supported in developing a pre-test once they had selected a topic. The teachers then collaboratively planned a unit of work that incorporated Matific

episodes. The teachers at School C designed separate units of work. Five to six students from each class group (except for School E, where one combined group was formed from two classes) participated in a focus group discussion to gauge their engagement with mathematics, their perceptions of mathematics teaching and learning, and their views and experiences of using technology during mathematics lessons.

During the second stage of the study the teachers implemented the unit and students completed a post-test on its conclusion. The researcher/s returned to the school and conducted individual interviews with each participating teacher to discuss their reactions to using Matific. Student focus group discussions were also held to investigate changes in students' perceptions as a result of using Matific. The various units of work were finalised and are published as an appendix to this report along with copies of the pre- and post-tests.

Participants

The participants in this project consisted of 16 teachers with a wide diversity of experiences in teaching. The majority did not use technology as a regular part of their mathematics lessons and none had used Matific prior to this project. Table 2 provides details of the teachers and their class groups.

School	Teacher (pseudonyms)	Experience	Grade	No. of Students	Unit of Work Topic
A	Nathan	Early Career	2	24	Number (partitioning 3-digit numbers)
	Julie	Late Career	2	24	
B	Annette	Early Career	3/4	30	Time
	Ellen	Mid Career	3/4	30	
C	Sean	Late Career	5	23	Mass
	Lisa	Mid Career	6	14	Area & Perimeter
D	Janette	Mid Career	4	29	Fractions
	Damien	Late Career	4	27	
E	Kerry	Mid Career	6	22	Order of Operations
	Lachlan	Mid Career	6	22	
F	Alana	Mid Career	5	26	Fractions and Decimals
	Deena	Mid Career	6	21	
G	Caitlyn	Mid Career	5/6	24	Angles
	Sharon	Late Career	6	22	
H	Chelsea	Late Career	6	31	Fractions (addition and subtraction)
	Donna	Late Career	6	30	

Table 2: Teacher Participants

Data Collection

Each of the teachers participated in a semi-structured interview at the conclusion of the project. The interviews consisted of the following prompts:

- Tell me about your experiences with the Matific resources.
- Are there other digital resources you use to enhance mathematics learning?
- Can you talk about some of the ways you incorporated the Matific digital resources?
- Were the resources incorporated into homework, and if so, what were the perceived results?
- What were your students' responses to the use of the resources?
- What are your perceptions of the Matific resources in relation to addressing the needs of your students?
- Can you talk about any changes you observed in the students' learning during the unit and as a result of the post-test?
- What information did you gain from the pre and post-tests?
- What are your observations in regard to your students' engagement in mathematics?
- What feedback or comments did you receive from parents or other stakeholders regarding the use of Matific resources during the unit of work?
- Have the Matific resources changed the way you use technology to teach mathematics?
- How do the Matific resources compare to other digital resources you have used previously?
- Are you likely to continue using these resources? Why?
- Can you talk about any improvements to the resources you would like to see and why?

Each of the teachers in the study sent invitations and consent forms to parents and caregivers. The focus groups at each school comprised of students who had returned signed consent forms to school. Each group consisted of five to six students and were of mixed gender.

The focus group discussions used the following prompts:

Initial Focus Group (prior to unit of work)

- Tell me about what you think about maths.
- Do you think maths is important?
- What sorts of things do you find difficult in maths lessons?
- What sorts of things does your teacher use to help you understand maths?
- How and when do you use computers or iPads to learn maths?
- Imagine a perfect maths lesson. What would it look like and what would you be doing?

Final Focus Group (following unit of work)

- Tell me about what you've been doing in maths and what you think about it at the moment.

- You've been doing some maths work with computers lately. Can you talk about what you've been doing?
- Has this work helped you learn maths? How?
- Can you talk about using computers/tablets to learn maths?
- What was the best thing about learning [insert topic]?

In addition to qualitative data, pre- and post-tests provided some quantitative information. The purpose of including this quantitative data was twofold. First, it allowed the participating teachers an opportunity to gauge the learning needs of their students in relation to the specific concepts within their chosen topic. Second, results allowed the teachers and researchers to measure growth in student understanding as a result of the students' participation in the units of work that incorporated the Matific resources. It is acknowledged that any growth between the pre- and post-tests cannot solely be contributed to the use of Matific resources due to the many other variables involved in student learning and issues relating to student performance in pen and paper test environments.

Data Analysis

Each participating school in this project was treated as an individual case. Qualitative data was audio-recorded and transcribed verbatim. Data from each school was analysed separately and coded prior to being organised into themes. A cross-case analysis was then conducted to seek common themes across the group of eight cases.

The indicator used to measure student improvement, labelled the Improvement Index, was used as a percentage number derived from the number of marks scored by all students in the pre- and post-tests. The Improvement Index was then calculated by finding the percentage increase of the available marks. That is, the total of all percentage marks in the pre- and post-tests were calculated and the difference between these values is the increase that is then divided by the number of available marks found by subtracting the pre-test total from the total marks available. This provided a single figure method of comparison that indicates the level of improvement of all students and allows comparison between schools irrespective of the initial ability level of the students. Simply stated, the Improvement Index is the percentage of the available marks that students gained over the pre-test. An Improvement Index of 100% would mean that all of the students scored 100% in the post-test while an Improvement Index of 0% would indicate that the students did not improve at all from the pre-test.

The Improvement Index is designed to indicate if students have improved from the pre-test as a result of participating in the learning unit. To compare schools, the Improvement Index needs to be considered in conjunction with the post-test score. One school could have a higher improvement index but their students may not be performing as well as another school with higher pre-test results and a lower Improvement Index. However, as it is the

improvement pre-test to post-test that is the important factor, the start and end points are not considered. It is the improvement that indicates if learning has taken place. As schools had students in different years and attempted different units for varying durations, then individual school comparisons are not valid.

Ethics

The Western Sydney University Ethics Committee and the various school systems involved in this study provided approval. All participants were provided with a plain language information sheet about the study and all provided consent to participate. These documents outlined the research aims and activities, as well as the participants' rights to confidentiality and anonymity.

Findings from this project will first be presented as eight separate case studies. Following this, themes that have emerged across the case studies will be discussed followed by recommendations that arise from the study.

FINDINGS

School A

School A, situated in a high socio-economic area of Sydney, is a school where students generally achieve high academic outcomes that are often supplemented by attendance at external tutoring colleges. The participating students in this evaluation were two Year 2 class groups. One of their teachers, Nathan, was in his first year of teaching. The other, Julie, had over twenty years of experience. The school has small numbers of iPads available for each grade group to share, and has a computer lab set up with desktop computers. Each class has access to the lab for one hour per week.

Students' Attitudes to Mathematics Prior to using Matific

When discussing their perceptions of mathematics prior to using Matific, the Year 2 students at School A appeared to display positive attitudes towards mathematics. The students talked about division as being a difficult aspect of mathematics. Interestingly, when asked about the importance of mathematics, the students did not talk about real life applications. Rather, they discussed how it is important to learn mathematics for future educational opportunities such as university study and future employment. This is likely due to the number of students who attend external tutoring colleges and the local culture of high expectations and high achievement.

A significant amount of the students' discussion was focused on mathematics testing and the National Assessment Program for Literacy and Numeracy (NAPLAN) which was still one year away for these particular students. Their discussions also implied that mathematics has been learned through a traditional, drill and practice approach (possibly a result of tutoring), and there was discussion about learning 'maths tricks'.

When asked about technology use in their mathematics lessons, it appeared that there had been minimal use of technology in Julie's class, with lessons following a traditional worksheet-based approach. Nathan's students referred to using iPads, with one child stating that: "You can do any type of maths" (Year 2 student, School A). However, it appeared the students used iPads to access some mathematics within their home environments and occasionally at school through the use of games: "…to see who is quicker, faster" (Year 2 student, School A).

Using Matific

The teachers designed a unit of work based on the Whole Number sub-strand, specifically exploring the use of open number lines to partition three digit numbers (Appendix 1). The topic was selected as it had been identified from previous assessment tasks as an area of need. The following Matific episodes were selected for use within the unit:

- Toe the line
- Piled up

- Ship it out
- Bubble add up

The unit of work spanned three mathematics lessons. Each of the teachers incorporated the Matific resources in different ways. Julie utilised the weekly class visits to the school computer lab and this meant Matific was used separately to her classroom mathematics lessons. Although she had access to the use of some iPads, she opted to use the desktop computers for this reason:

> *Because with the iPads you usually just get a small amount, you know, and you don't have a whole class there, so I just thought at least if they are all in there in the computer room and they are all logged on and are being overseen to make sure everybody is doing it, then that way … there is no excuse (Julie, Year 2 teacher, School A).*

Julie also made this comment in regard to how Matific was integrated into her teaching program: "…it was just to supplement it really. I mean obviously the main learning is taking place in the classroom and some hands-on practical things we were using there. But this was different, a good follow up." In addition to their time on Matific in the computer labs, Julie set episodes for homework but made no comment on whether this was a successful strategy.

In Nathan's classroom, the students accessed Matific on their iPads during mathematics lessons as part of their group activities. Nathan also utilised the school's computer lab to allow his students further access to Matific. Within the unit of work Nathan provided differentiation by allocating different levels of Matific episodes to different students according to their academic needs. He also set Matific episodes for homework and allocated additional episodes for students who needed to be extended.

Students' Perceptions of Matific

On completion of the unit of work, the students participated in their second focus group discussion. There was a clear shift in the focus of their discussions when compared to their initial focus group. Although the students had positive attitudes, they were much more animated when talking about mathematics. What was most noticeable were the references relating to mathematics being fun, with one student saying: "I like how we do maths, it is just really fun for me now" (Year 2 student, School A). Incorporating Matific episodes into their mathematics learning had a significant impact on this group of students.

One feature of Matific that was commented on by the students in Nathan's class was the ability for activities to be differentiated to suit a diversity of abilities. One student from Nathan's class made this comment: "the teacher sends not very good people at maths, easy ones, but sends experts at maths hard ones" (Year 2 student, School A). This particular student also felt his mathematics had improved as a result of using the Matific resources.

A student from Julie's class talked about the different levels of Matific episodes and being given a choice in terms of which level to play, saying: "...so if you don't really know you can just go to the easy one - if you are getting used to it you can just go to the end one so you can challenge yourself" (Year 2 student, School A). Being provided with choice is featured in the FEM as an important contributor to student engagement.

The gradual increase in difficulty within each Matific episode was also a feature of focus group discussions in both groups of students and the following comment is representative of the students' overall comments:

> *...pretty much the best thing about Matific is because the last ones are pretty hard and it can teach you things. Like the first one gets you started with it the second one can make you like, can be a tiny bit tricky, and then the middle one is easy and hard, and then it goes quite hard. So the good think is it is quite hard and they can teach you more (Year 2 student, School A).*

The increase in difficulty within the episodes appeared to contribute to students' cognitive engagement, aligning with the FEM element: *tasks are positive, provide opportunity for all students to achieve a level of success and are challenging for all.* The students felt they were learning when the questions were challenging: "Some of the questions were easy and some of them are hard, and yet it makes me learn more" (Year 2 student, School A). In addition to recognising that they were learning as a result of the challenging questions, the students were able to talk about the mathematical skills or content within the episodes: "When we were doing the *Toe the Line* it helped me with my skip counting" (Year 2 student, School A).

The reward system built into the Matific episodes was an important feature for the students at School A. The star system and accompanying fireworks and accolades such as 'super awesome' promoted perseverance amongst the students, who were motivated to continue trying each episode until they achieved five correct answers, with one student commenting: "It took about six or seven goes for me and I got all of them". Given that these students are only approximately seven years of age their willingness to have several attempts at each episode is impressive. The positive reinforcement within the episodes promoted confidence in the students, and typical comment were: "I feel good once I have earned all the stars" and "When I got something wrong, I wanted to do it again" (Year 2 students, School A).

Of course, as with any resources, there were negatives aspects: "If I do too much I kind of know all the tips so it doesn't real`ly help me that much" (Year 2 student, School A). When the students' understanding does not progress regardless of the embedded scaffolding, the teacher needs to be aware and provide remediation. The students talked about how there was a danger of becoming bored with the episodes. This may relate to the small number of questions within each episode. When compared to the typical digital games that students play outside the school, the Matific episodes are quite short. This is not necessarily a negative aspect, just different to what the students are used to. The benefit of shorter

episodes is that they are able to target very specific mathematical concepts and skills that allow the teacher to address identified student needs in a very focussed manner.

Finally, the students had some advice for Matific. They requested that more questions and levels be added to the episodes, and clearer explanations be provided: “Sometimes I needed the teacher to actually explain it” (Year 2 student, School A).

Teachers’ Perceptions of Matific

Julie and Nathan had similar responses to Matific, although they incorporated the episodes into their teaching in slightly different ways. Each of the teachers had limited experience with other digital resources such as *Mathletics,* however, they were both positive about their experiences with Matific and indicated they were planning on continuing its use.

Both teachers felt the resources allowed them to target the specific needs of their students. The students’ record of achievements with Matific allowed each teacher to tailor other classroom activities in response to their students’ needs. Nathan made the following comment in reference to his ability to set different episodes for different students: “...because all the other kids didn’t realise, because it looks the same, but I know the content is different” (Nathan, Year 2 teacher, School A). Nathan also felt the affordance of being able to allocate tasks to students within their individual accounts appeared to promote autonomy amongst the students:

> *So instead of just working with one group at a time I could set the whole task and know that each kid is doing the activity I want them to, not just waiting until I come and work with them (Nathan, Year 2 teacher).*

On the other hand, Julie, who took a different approach and set all episodes for all students to complete, felt that some of the episodes could have been more challenging. She commented that lots of students were achieving 100%. This is understandable given Julie allowed all students access to all levels of each episodes, and conflicts to some degree with what her students were saying about trying hard and repeating episodes. If Julie is focusing on the end result of 100% rather than the attempts and the academic growth between each attempt, then perhaps the episodes would appear easy. One would also consider an achievement of 100% a sign of successful learning. Regardless of the level of difficulty of tasks, Julie did admit that students who already understood the content within the easy episodes were able to build on their fluency, an importance component of the Proficiencies (Australian Curriculum and Reporting Authority, 2012) and Working Mathematically (Board of Studies New South Wales, 2012) curriculum strands.

Julie talked about where she felt her students had learned from Matific and made this comment: “I think they don’t realise they are actually learning at the same time” (Julie, Year 2 teacher, School A). Again, this conflicts with her students’ comments, and may be related to the fact that there were no opportunities for student reflection built into Julie’s lessons. In Nathan’s class, the students were encouraged to talk about their learning and he believed

the Matific episodes promoted reasoning and mathematical communication, aligning with curriculum requirements and the FEM, where continuous interaction amongst students is encouraged.

Negative aspects of Matific, as reported by Julie and Nathan, were mostly related to initial difficulties with students failing to remember their passwords. The teachers also found that Matific episodes were easier to use on desktop computers rather than iPads. Nathan suggested that it would be beneficial if star ratings could be re-set to allow students to re-attempt episodes at a later date.

Engagement with Mathematics

Both teachers at School A noticed significant changes in student engagement during their use of Matific. Julie talked about how her students were so enthusiastic they wanted to access the episodes that were allocated for their computer lab time before they got to school, so to avoid this, she had to ensure episodes were allocated within school hours. This is what Julie said:

> *I had to not post it until I know that they are going to get to school because I think they would be at home doing it. So it gets really engaging. I think, not just the graphics but the activities too, they are a really good range (Julie, Year 2 teacher, School A).*

Nathan reported that his students' love of technology partially attributed to their improved engagement with mathematics. He also felt that the reward system promoted high engagement, making this comment: "I set them extra tasks and said once you have the five stars for all the tasks then you go on to more and so they just went on to more activities until I said stop." (Nathan, Year 2 teacher, School A). The teachers' beliefs that Matific improved their students' engagement is reflected in the students' focus group discussions, with this quote a typical one: "So basically it is fun and you also get to learn stuff which is pretty good" (Year 2 student, School A).

Academic results

The pre-test comprised seven questions that required students to use number lines complete calculations and describe methods used to answer questions. The post-test used the same questions as the pre-test with the numbers changed. Both classes completed the same tests. The results are summarised in Table 3 and copies of the pre and post tests are in Appendix 2.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Julie	76%	84%	30%	Student A 57% to 14% Student B 79% to 57%
Nathan	56%	71%	30%	Student C 50% to 21% Student D 71% to 36%

Table 3: School A Results

Nathan

The students in Nathan's Year 2 class scored an average mark of 46% on the pre-test and an average score of 71% on the post test. This shows improvement in students' understanding. Nathan stated: "I know the tests are just a little snapshot of what they could do at that moment. But there is definitely an increase in what they did and what they could do." The improvement index for that class was 30% which indicates that there was significant growth in students' understanding. However, two students had a significant decrease in their performance, one from 50% to 21% and another from 71% to 36%, which indicates that these students would need further assistance. Later Nathan spoke about using the pre-test to determine which activities would be appropriate for each individual student with the use of Matific and tailoring the selection of Matific episodes to suit the needs of the individual.

Julie

The students in Julie's Year 2 class scored an average mark of 76% on the pre-test and an average score of 84% on the post-test. This shows that while the students already had a high level of understanding before the unit was presented there was improvement in students' understanding as a result of the unit. In fact, this class began at a higher pre-test average than the other class's post-test average. This demonstrates the large differences in ability between classes and is indicative of children at such a young age. The improvement index was 30% indicating growth from what was originally a very high base.

However, two students had a significant decrease in their performance, one from 57% to 14% and another from 79% to 57%. Julie stated that: "There weren't a lot to be honest that weren't – probably only two or three that weren't going very well." As the tests were modified from the previous activities on this topic some of the students may have experienced increased difficulty as a result. With respect to one of those students Julie said "His language skills aren't great. I know he really struggled with that."

School B

School B is situated within a low-socio-economic semi-rural pocket of south-west Sydney. The school has a multicultural population with students predominantly of European backgrounds. At this school the participating students were from two Year 3 and 4 composite class groups. One of their teachers, Annette, was in her second year of teaching, and the other, Ellen, had over ten years of teaching experience. The school has a small number of iPads for classroom use as well as a shared computer lab within the school library, set up with desktop computers.

Students' Attitudes to Mathematics Prior to using Matific

Prior to using Matific, the students in the two focus groups indicated they had a range of feelings towards mathematics. For some, mathematics elicited feelings of anxiety, particularly when being introduced to new mathematics content. One student commented: "It makes me worried because I don't know what to do and then I might get the answer wrong", while another said: "I don't really like it but it helps me learn" (Year 3/4 students, School B). For other students, mathematics was perceived as hard, fun and challenging, indicating some levels of engagement and a generally positive attitude. Most of the participating students considered mathematics to involve hard work, with one student commenting: "it gets your brain sweating more than a lot of other things", considering mathematics to be more difficult than other subject areas.

Students from both focus groups discussed their previous experiences with digital technology and mathematics. It appears both groups had used digital technology more extensively in past years with different teachers. Some had used *Mathletics* and others had used *Study Ladder*, with one student saying: "I like *Study Ladder* because it's got some problem solving and I like to be challenged". In terms of devices, the students talked about using iPads at school and at home, indicating that using iPad apps was helpful in learning mathematics. It appeared that the students' use of digital technology in the past was predominantly through a games based approach. Students also talked about using mathematics games on their iPads at home.

Using Matific

Annette and Ellen designed a unit of work based on the concept of time (Appendix 3). They selected this topic for revision purposes as the students had already covered content relating to time earlier in the year. The Unit consisted of a total of six activities that included a full set of group rotation activities. The Matific episodes that were integrated into the unit were:

- Stop the Clock (hours/half hours)
- Stop the Clock (before and after)
- Stop the Clock (digital and analogue time)

- Stop the Clock (minute)
- The Monster Share (halves)
- Know the Half of It (halves and quarters)

As would be expected, each teacher implemented the unit of work in different ways. Annette used the results from the pre-test to allocate specific episodes to her students. However, she did not use the full functionality of Matific to monitor her students' progress, which may have influenced her overall impressions of Matific. Issues with the availability of iPads meant that the use of Matific was limited to the class's scheduled time in the school computer lab.

In both classrooms Matific was used to demonstrate concepts using the IWB, and then used for practice during computer lab time. Unlike Annette, Ellen chose not to differentiate the use of Matific, saying:

> *No they had their own choice so I didn't specify which one I just let them go. I said if you're comfortable with the half past go to the next one with the 5 minutes so they had free range (Ellen, Year 3/4 teacher, School B).*

Neither teacher used Matific for homework tasks because the homework for each grade was set at the beginning of each school term. Both teachers gave their students the option of using Matific at home to supplement their mathematics lessons and this was taken up by several students in Annette's class but no students from Ellen's class.

Students' Perceptions of Matific

Student perceptions of Matific at School B tended to reflect those of their teachers. Annette's students were more enthusiastic than Ellen's, with some very positive comments such as: "Matific is a good website and I really like it", "It was fun and we got to learn more stuff on clocks" and "I already know time but it made me learn more than I used to". When asked what made Matific fun, one student said: "You weren't on a sheet of paper and stuff", implying the move away from the static worksheet was more affectively engaging. Annette's students also indicated they liked the way the program provided scaffolding when answers were incorrect, and they indicated that they were motivated to repeat the activities in order to achieve the 'super awesome' feedback.

There seemed to be inconsistencies in the student experience within Ellen's class. One student expressed a sense of frustration, saying: "it had lots of glitches", while another student talked about his positive experiences:

> *One of the disadvantages about it is that sometimes it starts far away from the actual time, and for some people when it stays stopped on the right time it said they were wrong, but when I stopped it on the right time it told me it was right, and I like it and it was nice and easy, and no glitches (Year 3/4 student, School B).*

Students from Ellen's class were less enthusiastic than those from Annette's. Most felt that they already knew the content being covered. Ellen's students appeared to feel that their learning needs were not being met, with one student saying: "It's not as good, because the people that are higher level in time and maths think it's too easy and can't really learn from it because they already know", implying a desire to have an appropriate level of challenge within each episode, and aligning with the FEM statement: *tasks are positive, provide opportunity for all students to achieve a level of success and are challenging for all.*

The students in Annette's class indicated they wanted to continue using Matific, however the students in Ellen's class were undecided.

Teachers' Perceptions of Matific

The teachers from School B had mixed reactions to Matific. Annette spoke positively about the affordance of being able to personalise the tasks to address student needs. She talked about how she planned its use and how her strategy engaged her students in the following comment:

> *... we started off with the pre-test and I gave them feedback immediately afterwards and I had explained to them that I had grouped them so they knew they were grouped based on the pre-test. The kids were really aware of their goal for 'time' so because they were aware of their goal for time and because they knew that it was linked with Matific and the activities there they were conscious of their learning more. So, they were 'oh I need to do this game; this is going to help me and meet my goals so I can move to the next goal.' So yeah they were good with that. They loved having those goals and they knew that it was related to the Matific game that I had assigned to them (Annette, Year 3/4 teacher, School B).*

Ellen, however, was quite negative about Matific and made this comment about her students and their reactions to Matific: "Some of the kids loved the activities and some of the kids said it was boring. It took too long every time the hand would pass something, so I found it very time consuming for the outcome" (Ellen, Year 4/5 teacher, School B). Ellen was referring to issues they had with the Stop the Clock episodes as well as issues with the speed of loading the Matific episodes. She also felt that episodes designed to address the topic of time were limited, saying:

> *I don't feel that it gives you enough options with different levels and different abilities. Sometimes you'll have one game and you'll think oh that's okay and you'll go to the next one and it's either jumped too many steps to the next game so I think there's not enough increments leading up to other games and other challenges (Ellen, Year 3/4 teacher, School B).*

Ellen admitted that perhaps the topic of time was not the best one for trialling Matific, however her use of Matific's affordances was limited, particularly when she had experienced technical issues, did not differentiate the tasks, and did not track student achievement or assign Matific as homework. Annette commented that a feature she liked

was the links to the curriculum and Numeracy Continuum. These assisted with planning and saved her time searching the Internet for other digital resources. Although their experiences were not all positive, both Annette and Ellen stated they would be willing to try using Matific again in other mathematics topics.

Engagement with Mathematics

Annette felt that her students were engaged with mathematics as a result of using Matific, saying: "They did really enjoy the activities and they enjoyed having their own activities, so they were quite engaged" (Annette, Year 3/4 teacher, School B). She talked about her students' awareness of their pre-test results and how having learning goals relating to their test achievements promoted higher engagement with mathematics and with the Matific episodes:

> *...they felt they had learnt from it. So they were asking me to do the post-test because they said 'oh I'm better at it now, look at me, look how I can tell the time' and they were showing me. So whether or not that was because of their goal or whether it was related to Matific. I think maybe they work hand in hand (Annette, Year 3/4 teacher, School B).*

Although Annette did not assign Matific homework, an indication of her students' engagement was their willingness to access the Matific episodes at home. One parent approached Annette with positive feedback:

> *I had one parent who said that her daughter was really excited about it and she was using it at home so she was one of the kids who had memorised her log in and she took it home and was using it (Annette, Year 3/4 teacher, School B).*

Although Annette's students were engaged, Ellen believed they weren't, and she made this comment: "...not very engaged and I think it's because they were comparing it to a lot of the other online games that they might use at home or that we've used before" (Annette, Year 3/4 teacher, School B). Likewise, Ellen's students felt that Matific hadn't engaged them due to the fact that they perceived the tasks to be pitched at the wrong academic level for them and the activities didn't meet their learning needs.

Academic Results

The pre-test comprised 19 questions that required students to write the time indicated on digital and analogue displays. They needed to convert time units and find the lapsed time. The post-test comprised 12 questions and used similar questions to the pre-test with the numbers changed. Both classes completed the same tests. The results are summarised in the Table 4 and copies of the pre- and post-tests are in Appendix 4.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Annette	38%	45%	12%	Student A: 90% to 75% Student B: 23% to 0%
Ellen	39%	40%	2%	Student C 50% to 35%

Table 4: School B Results

Annette

The students in Annette's Year 3/4 class scored an average mark of 38% on the pre-test and an average score of 45% on the post test. This shows improvement in students' understanding. The improvement index for that class was 12% which indicates that there was some growth in students' understanding. However, two students had a significant decrease in their performance, one from 90% to 75% and another from 23% to 0%, which indicates that these results would need further investigation by Annette. Annette spoke about using the pre-test to determine which activities would be appropriate for each individual student with the use of Matific and tailoring the selection of Matific episodes to suit the needs of the individual.

Ellen

The students in Ellen's Year 3/4 class scored an average mark of 39% on the pre-test and an average score of 40% on the post-test. This shows that the students had a low level of understanding before the unit was presented there really was no improvement in students' understanding as a result of the unit. The improvement index was 2% indicating no real growth at all. One student had a significant decrease in his performance, from 50% to 35%, which indicates that he needs further assistance. Ellen stated: "It's funny 'cause then at the post-test a few kids went backwards and a few kids who did increase only increased marginally, it was only a little bit and I did spend a bit of time on it so I was hoping for better results I suppose" (Ellen Year 3/4 teacher, School B).

School C

School C, situated in a high socio-economic area of Newcastle, is a school where students generally achieve high academic outcomes in literacy and average academic outcomes in numeracy. The participating students in this project were in Year 5 and Year 6. The teacher of Year 5, Sean, has many years of teaching experience. The teacher of Year 6, Lisa, is also an experienced teacher. The school has a computer room that classes book for access of approximately one hour per week.

Students' Attitudes to Mathematics Prior to using Matific

When discussing their perceptions of mathematics, the Year 5 students at School C said that "…maths has got harder over the years". There was a focus that mathematics is important to learn at school so that they can obtain future employment. Students stated: "I think it's better for our education, so we can get a better job" and "…it will be easier for us to choose our own jobs if we are good at maths" (Year 5 students, School C).

There was significant discussion about the National Assessment Program for Literacy and Numeracy (NAPLAN) which had recently been completed by these students. They spoke about the amount of time that the teacher focussed on preparation: "…we did a lot of practice on it" (Year 5 student, School C).

Prior to the use of Matific the students used technology sporadically and mainly for drill and practice on multiplication tables. Students commented that they enjoyed playing games on the computer and would have liked to use technology more often: "I love playing games on the computer; I don't really mind if they're educational or not" (Year 5 student, School C).

The Year 6 students had the perception that mathematics is hard but important for future employment: "I don't really like maths but I do think it's very important to learn". The students seemed to lack engagement in mathematics and expressed frustration and confusion: "…confused so you get frustrated" (Year 6 student, School C).

The mathematics lessons experienced by the students at School C appear to be mainly teacher-centred with the IWB as the main, if not only, type of technology utilised. When asked about the use of technology other than for research purposes the students could not give any examples for the current term and the consensus was that there had not been any at all.

When discussing their perfect mathematics lesson, the Year 6 students spoke about wanting lessons that were differentiated so that all students could achieve success or that their perfect maths lesson would be very short or have no maths at all: "… so long as it was only thirty seconds long" (Year 5 student, School C). Many of the students did use computers and various websites at home and indicated their desire to do so: "I just go on the computer and I forget what the website is called but it's like this maths thing" (Year 5 student, School C).

Using Matific

The Year 5 teacher designed a unit of work based on the Measurement and Geometry strand with a focus on mass, specifically the units for measuring mass, conversions between mass units, gross and net mass (Appendix 5). The topic was selected as it was scheduled for the next few weeks and the teacher felt that there were suitable Matific resources available. The following Matific episodes were selected for use within the unit:

- Weighing Riddles-division
- Weighing the options
- One in a hundredth
- Weighing Riddles-multiplication
- One in a hundredth-model with decimals
- Weighing Matters

The unit of work spanned four mathematics lessons over the period of one week. The Matific resources were set for every student in the class and they were instructed to work systematically through all of them during the one-hour computer lessons, on desktop computers, in the library. The Matific resources were used mainly as background material in this unit. Sean commented that there were some gaps in the Matific resource availability in this particular unit: "I'm in class doing net mass and gross mass and the tonne and the activities that they're doing on Matific weren't anything to do with that" (Sean, Year 5 teacher, School C). He did not set Matific episodes for homework.

The Year 6 teacher, Lisa, designed a unit of work based on area and perimeter focussing on measurement units and the distinction between area and perimeter (Appendix 7). The topic was selected as it was the next topic according to Lisa's scope and sequence plan. The following Matific episodes were selected for use within the unit:

- Park Planning
- Shapes on the Grid – Right Triangle
- Cover by rectangles
- Split and Conquer
- Air and Square
- Shapes on the Grid-area estimation
- Fenced in – level II
- Fenced in – level III

The unit of work spanned four mathematics lessons over a one-week period. Lisa differentiated the Matific episodes based on the pre-test and her knowledge of the students: "…we did the pre-test and then I actually analysed and broke the pre-test down". However, she did not use the allocation through Matific but personally instructed the students on which activities to complete: "I said to different kids, right you're going to do activity 1 and 2, or you're going to do task 3 and 4, depending on what their ability level

was" (Lisa, Year 6 teacher, School C). The students went to the computer room and used desktop machines to access the Matific episodes as the school has Wifi issues in the classrooms.

While Sean used the Matific episodes as mainly providing background understanding to the content of his unit, Lisa saw the Matific episodes directly pertinent to her unit: "Yeah, so I thought it was for area and perimeter, it was very relevant and very appropriate to what the outcomes were for the unit" (Lisa, Year 6 teacher, School C). There were no Matific episodes set for homework.

Students' Perceptions of Matific

Following the unit of work, the students participated in their second focus group discussion. The students were much more animated when talking about mathematics and were able to be quite specific about aspects of their learning.

In Year 5 what was most noticeable were the references relating to the Matific exercises being helpful "It was really helpful, it helped me a lot with it", and mathematics being fun, when asked about continuing to use Matific one student saying: "Yes, because it's fun" (Year 5 student, School C). Incorporating Matific episodes into their mathematics learning had a significant impact on this group of students.

The immediate feedback provided within the Matific episodes was an important feature with the students commenting that this allowed them to learn from their mistake and correct the error immediately: "Because knowing whether it's right or wrong straight away you can have a think about it or see if you need to change something again" (Year 6 student, School C). The provision of examples into the episodes was a positive feature of Matific: "…it was easier because you had the instructions written" (Year 5 student, School C).

The reward system built into the Matific episodes was an important feature for the students in Year 5 at School C. The star system and accompanying fireworks and accolades such as 'super awesome' promoted perseverance amongst the students, who were motivated to continue trying each episode until they achieved five correct answers, with one student commenting: "When I get one of the activities wrong – even if it's just one question I go back and do it again and make sure I get five stars on it" (Year 5 student, School C).

When asked about incorporating Matific exercises as homework the response was positive. Even though some of the students were not keen on homework they had a different attitude when it came to Matific: "I would love to have Matific in our work tasks and I would love to have it for homework as well, because I'm not much of a fan of homework" (Year 5 student, School C).

Students found an error in an episode and that dominated the initial part of the conversation indicating that small issues can make a big difference to the user experience:

"When they said which one was the heaviest, when really they meant lightest" (Year 5 student, School C).

The Year 6 students agreed with the sentiments of the Year 5 students as they found the Matific episodes to be helpful in their understanding of mathematical concepts: "I think it's (maths) more easier now, since we've been going on the Matific thing" (Year 6 student, School C). A student who stated he hated maths and that the best maths lesson is no lesson at all changed his viewpoint considerably after using Matific: "I think it's helped me quite a lot to understand area and perimeter. It's a good, well created website too" (Year 6 student, School C).

The immediate feedback was appreciated by the Year 6 students and the demonstration after three incorrect responses was seen as a useful aspect of Matific: "because when I got it wrong three times it helped me understand, because I didn't really know what I got wrong" (Year 6 student, School C). Another student found that the explanation assisted her with her learning: "It helped me because it showed me what to do".

The Year 6 students wanted to continue to use Matific in their future mathematics units as they could see the value in the episodes: "I would use Matific, because it's fun and it gives you something to like look at…" (Year 6 student, School C). In fact, they would like to use it for homework as well: "I would rather have Matific because it's simple and fun, and it has good instant feedback".

There were some minor technical issues experienced with some of the computers lagging, but this was isolated.

Teachers' Perceptions of Matific

The Year 5 teacher, Sean, felt that the use of Matific resources focused the students on the topic for the week and that it encouraged mathematical conversations among the students. Sean identified from the pre-test that the students needed further assistance with decimal notation and recording mass: "so the Matific lesson on that activity was helpful" (Sean, Year 5 teacher, School C). However, they also needed assistance with gross and net mass and there was no Matific episode for that aspect.

As all students were assigned all activities and the results were displayed on the IWB there was communication amongst the students with a focus on assisting each other to perform well in the Matific tasks: "…it was like a team effort in a way to help each other get in the green" (Sean, Year 5 teacher, School C). The mathematical communication among the students and the teacher was a direct result of the use of the Matific resources: "Matific sort of forced my hand there in a way. The kids were wanting to talk about it and wanting to get an understanding" (Sean, Year 5 teacher, School C). Sean expressed that he would be incorporating Matific episodes into his future units of work as they were student focused activities rather than teacher led activities:

> *I will go down the road of trying to set some in each of my units, put the links straight in my units so I can click on them straight away and as long as I can get access to the computers in the library yeah, I'll be using Matific within all of my weekly units if I can (Sean, Year 5 teacher, School C).*

The negative aspect of Matific expressed by Sean was the lack of resources in some areas. He suggested that there should be clear links with the syllabus: "The Matific tasks really need to dove tail in with the syllabus" (Sean, Year 5 teacher, School C).

The Year 6 teacher, Lisa, found that the students enjoyed the Matific episodes and that the site was easy to navigate and there was a good variety of episodes. The way in which Lisa differentiated the tasks meant that the students noticed the differentiation, whereas using the program to allocate would have reduced this aspect. The students were very enthusiastic about completing the Matific episodes and the fact that the most academically able students were still challenged by some of the episodes seemed to, in a positive way, surprised Lisa: "the degree of difficulty challenged even some of my top kids" (Lisa, Year 6 teacher, School C).

The way in which the language of mathematics is a focus of the Matific episodes was seen by Lisa as an opportunity to focus on the use of language to analyse, not just to use the visual of the episode: "the language they really had to be analysing and thinking what [is] the language asking me to do, and not just relying on the visual" (Lisa, Year 6 teacher, School C).

A negative aspect of Matific expressed by Lisa concerned the area of triangles, a concept that her students needed more assistance with but was not adequately addressed in the episodes: "The area of triangles was a big one they needed to work on and that was probably the only one that wasn't so much on Matific" (Lisa, Year 6 teacher, School C). While there were many episodes using rectangles and squares there was little on problem solving.

Engagement with Mathematics

Both teachers at School C noticed significant changes in student engagement during their use of Matific. Most of the students in Year 5 took particular interest in viewing their performance on the feedback charts and Sean indicated that this motivated the students for their next library computer session:

> *So they found that really motivating in themselves and even before they'd go down to the library they'd say to the computers they'd say can we have a look at what areas we need to work on, so they were asking me every day can we have a look at our charts, our score charts and the pie graph and all of that to see how they were going, so that was a really good feedback for them (Sean, Year 5 teacher, School C).*

However, some students in Year 5 felt pressure to obtain five stars and found the publication of results put them under pressure to get to five stars: "Yeah, I didn't really like

seeing them". Another student who achieved five stars on an episode after a number of attempts said: "I felt that the pressure was off".

The Year 6 students demonstrated a high level of engagement as Lisa stated they wanted to work with Matific: "they really enjoyed it and were very keen to get back to the library to have another go at Matific and they were very keen to do that certainly with high level enthusiasm" (Lisa, Year 6 teacher, School C). Students commented that they enjoyed using computers because of the visual, instant feedback and demonstrations and were keen to try again if they did not get five stars on an episode: "I want to try again, because I want to do better".

Academic Results

The Year 6 pre-test comprised eight questions that required students to calculate the area of rectangles, squares and triangles. The post-test used exactly the same questions as the pre-test. The Year 5 pre-test comprised 10 questions some with multiple sub parts which totalled 67 marks. It required students to perform calculations involving net and gross mass, convert between grams and kilograms, and to choose the appropriate measurement unit. The post-test used exactly the same questions as the pre-test.

The results are summarised in Table 5 and copies of the pre and post tests are in Appendices 6 and 8.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Lisa	52%	68%	33%	none
Sean	66%	81%	40%	none

Table 5: School C Results

The students in Lisa's Year 6 class scored an average mark of 52% on the pre-test and an average score of 68% on the post test. This shows improvement in students' understanding. Lisa used the results from the pre-test to differentiate the activities for the children in her class. "…so I could work out which areas of the Matific program to start different kids." Lisa used some Matific episodes from earlier years to assist in the areas that the students needed support. The improvement index for that class was 33% which indicates that there was significant growth in students' understanding. Importantly no student had a significant decrease in their performance. Following the post-test Lisa intends to focus on the area of triangles but there are limited Matific resources in that area.

The students in Sean's Year 5 class scored an average mark of 66% on the pre-test and an average score of 81% on the post-test. This shows improvement in students' understanding. Sean stated that the pre-test had alerted him that decimal notation and recording measurements were issues for the students in the class. He used some Matific resources

and other concrete materials to address these areas. The improvement index for that class was 40% which indicates that there was significant growth in students' understanding. Importantly no student had a significant decrease in their performance.

School D

School D is a large school of over 800 students in a low socio-economic suburb of south western Sydney. The school boasts a large multicultural population, with representation from over 60 cultural groups. The school has an Opportunity Class (a class for gifted and talented students) and it achieves above average results in NAPLAN. The two participating class groups at School D were Year 4 students and their teachers, Janette and Damien, both of whom had several years of teaching experience. Each of the classes had access to desktop computers, laptops and some iPads.

Students' Attitudes to Mathematics Prior to using Matific

When asked about their perceptions of mathematics prior to using Matific, each of the class groups had differing perspectives. Janette's group displayed a positive attitude towards mathematics although they did not appear to be confident in their abilities. Typical comments were: "I haven't reached my goal to become a very good person at maths", and "I don't get disappointed but I just think I need to work harder" (Year 4 students, School D).

Janette's students were able to talk about problem solving and specific strategies for mental computation. They also spoke a lot about the things Janette does to help them learn mathematics such as using concrete manipulatives, technology, and videos. Many comments aligned Janette's teaching methods with the FEM, with one student saying: "She makes things interesting, it makes it easier to learn" (Year 4 student, School D). These students had a positive disposition towards the use of technology in the mathematics classroom, indicating they have had some successful experiences with it. There were specific mentions of Maths Online, and games such as Reflex and Score-Ball. Students commented on the feedback and assistance in the Reflex app: "…when I do it, the crab tells me what to do and if I need help he just talks to me" (Year 4 student, School D), indicating an appreciation of the instant feedback that technology affords.

Conversely, the students in Daniel's class had little to say about their teacher's methods. This group of students related mathematics to computation, and perceived mathematics to be fun but also challenging. They indicated no use of technology in their mathematics lessons except for teacher demonstrations on an IWB, with one student stating: "the teacher uses it most in maths to show us" (Year 4 student, School D).

Using Matific

Janette and Daniel incorporated Matific into a unit of work on fractions and decimals (Appendix 9). The unit consisted of six lessons, and each lesson incorporated two Matific episodes that aligned with the content being taught. The episodes that were included were:

- Birds on the Wire
- Wholes and Parts
- Same Same 1

- Same Same 2
- All the Same to Me
- Who Got More Cheese?
- Weighing Matters
- One in a Hundred
- Toe the Line 1
- Toe the Line 2

In Janette's classroom Matific was embedded into each lesson in two different ways. First, she would model the Matific episode using the IWB, and then students would work in groups on the episodes. Because there were a limited number of devices, the students were required to share them and work collaboratively rather than independently. This meant that it was not possible for Janette to use Matific to track individual student achievement. Janette also gave her students the choice to use Matific for homework.

Daniel also modelled the Matific episodes on the IWB but instead of incorporating the episodes into the lessons as detailed in the unit of work, he used time in the school computer lab. This is what he said:

> *I demonstrated on the smart board as a whole class setting and we've got the new computer lab set back up so we had 19 laptops for our 29 children. So we spent about an hour and a half over two lessons doing the Matific activities that we did in class that linked to what we were doing…some were individual – half would have had their own lap top and half would have had to share so we would have had 9-10 up there. Our iPads were a bit unreliable so I didn't take up the iPads at the same time. We just literally used the 19 laptops (Daniel, Year 4 teacher, School D).*

Although he didn't set Matific episodes for homework, Daniel said he gave each student their password to take home. He did not check if any of the students had actually accessed Matific at home, making this comment:

> *I didn't quite catch up with how many actually used it. I'm guessing not many just like we use Maths Online here and most of them aren't actually using it at home so I'm guessing that most didn't use it. Probably had a couple of keen ones that would have gone home and used it as well (Daniel, Year 4 teacher, School D).*

Students' Perceptions of Matific

Students from Janette's class experienced mixed reactions to Matific. When asked about the mathematics they had been learning they discussed the unit of work that they had worked on but did not make any specific reference to Matific. When they were asked specifically about using computers and Matific they complained that the program lagged and that it took a long time to connect. This problem appeared to be a school networking issue.

When asked about the positive and instant feedback the students stated that the stars were boring and just being told 'awesome' was not really an incentive. They wanted something

more exciting. They felt they should have some choice in the format of the reward, and one student suggested skulls would be more appropriate.

The general consensus amongst Janette's focus group students was that Matific was too easy and boring and they preferred more visually stimulating games. While they felt that they learnt from using Matific they said that they would prefer not to use it again.

The students in Daniel's group had similar opinions, although they were more positive towards the use of Matific, with one student saying: "I think Matific's fun because it interacts with you". The students felt that Matific provided assistance when questions were difficult to answer. The level of difficulty also seemed to be an aspect of Matific that these students appreciated, with one student saying: "When it's too easy, it's boring" This comment reflects the FEM, which states learning needs to be challenging for engagement to occur.

Daniel's students were unsure if Matific helped them learn, and this is most likely related to the fact that the tasks were not differentiated – all students were allocated all tasks regardless of their ability and the pre-test data. Although the activities were modelled during their mathematics lessons, the time lapse between the lesson and the computer lab session may have also had some bearing on the students' reactions to Matific. When asked if Matific helped them learn, this student made the following comment and was typical of the group's responses: "Yes, but no. Yes, because the stuff that I didn't know it would help me, no, because some of the stuff I already knew". Daniel's students also felt they would not choose to use Matific again in the future.

Teachers' Perceptions of Matific

Daniel and Janette also had mixed reactions to Matific. Daniel's reaction was quite negative and at times conflicted with what his students said. It also appears that his use of Matific was quite limited in that he did not take advantage of the full functionality of the resource by differentiating the episodes according to his students' abilities, nor did he attempt to track his students' progress or access in class and as homework. Most importantly, Daniel felt his students found Matific too difficult, where his students claimed it was too easy. It is not possible to attribute the conflicting perceptions to a specific cause from the data collected, however the lack of differentiation and tracking may have been a contributing factor.

Janette discussed positive and negative aspects of Matific. Although experiencing significant network issues, Janette felt her students had learned as a result of using Matific. She made this comment:

> *It definitely satisfied the needs of the students. It helped them to reinforce concepts that I can't necessarily ensure they understand...it's hard to get around to every single child and I felt that it was...a learning place, it's a learning zone. It's not perfect but It's something I couldn't find in any other way (Janette, Year 4 teacher, School D).*

Like others in this project, Janette felt that the gradual increase in the level of difficulty within each episode as a good feature, saying "...but if they got halfway through it there was never any comments that this is getting too hard, I can't do it, disengagement, because I've seen it happen in other programs" (Janette, Year 4 teacher, School D). She also liked the idea of incorporating Matific for homework and used it for students to practice the episodes they had already used in class. She felt that doing this was an opportunity for to promote conversations about mathematics amongst students and their families.

Although the limited number of devices resulted in Janette's students having to work in groups, she felt the collaboration that resulted was one of the best benefits of using Matific. The episodes generated mathematical discussions amongst the students, allowing them to address the Working Mathematically components of the NSW mathematics curriculum. Such discussions are also highly beneficial for the students at School D, many of whom come from non-English speaking backgrounds.

When asked if she would be likely to use Matific in future, Janette said yes. As a user of a range of technology, she said:

> *Every single app, every single bit of technology, it's got its place and I think definitely Matific is different to Maths Online. Maths Online is almost a lesson in itself, whereas Matific is the reinforcement of that concept and so I don't use a lot of Maths Online in the classroom. I would be more likely to use Matific (Janette, Year 4 teacher, School D).*

Engagement with Mathematics

Janette felt her students were engaged with mathematics when using the Matific episodes and commented on how the focus on an individual concept within each episode was beneficial for her students, saying:

> *What I like is you're not clouding it with other areas. It's pure in that it's just that area and it's again reinforcement, I like that. Some activities kind of blend into 100 different ones and we lose something there (Janette, Year 4 teacher, School D).*

Although his responses to Matific were mostly negative, Daniel did make the following positive comment that implied his students were cognitively engaged and were learning when working with the 'Who Got More Cheese' episode:

> *The ones that were struggling with the equivalent fractions and the cheese, they soon caught on fairly quickly that it was a visual sort of question too. They didn't have to worry about just the numbers in their head. They could also look at the slice of cheese and work out is the top slice in line with the second one – they soon caught on pretty quickly, so yes, I think they got the concepts (Daniel, Year 4 teacher, School D).*

Academic Results

The pre-test comprised seven questions that required students to use number lines complete calculations and describe methods used to answer questions. The post-test used

the same questions as the pre-test with the numbers changed. Both classes completed the same tests. The results are summarised in Table 6 and copies of the pre and post tests are in appendix 10.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Janette	46%	66%	36%	none
Daniel	36%	51%	23%	none

Table 6: School D Results

Janette

The students in Janette's Year 4 class scored an average mark of 46% on the pre-test and an average score of 66% on the post test. This shows improvement in students' understanding. The improvement index for that class was 36% which indicates that there was significant growth in students' understanding. There were no students who had a significant decrease in their performance.

Daniel

The students in Daniel's Year 4 class scored an average mark of 36% on the pre-test and an average score of 51% on the post-test. This shows that there was improvement in students' understanding as a result of the unit. In fact, this class began at a higher pre-test average than the other class's post-test average. The improvement index was 23% which indicates that there was significant growth in students' understanding. There were no students that had a significant decrease in their performance. Daniel did not use the information from the pre-test to allocate the Matific episodes.

School E

School E is a K-12 Catholic school situated within a regional town of average socio-economic status. The town has a population of 10,000 and is located in the Central West of NSW relying on farming and tourism. The school has over 400 students, and achieves slightly above average results in the numeracy aspect of NAPLAN. The two participating teachers, Kerry and Lachlan, teach Year 6. Both Kerry and Lachlan have been teaching for approximately 10 years each. Prior to the use of Matific the teachers and students used small laptops that were shared amongst classes, and an IWB. During the Matific project they were able to access additional computers from the secondary classrooms at the school.

Students' Attitudes to Mathematics Prior to using Matific

At School E there was only one focus group consisting of students from both Year 6 classes. When asked to talk about mathematics prior to using Matific, the Year 6 students discussed how important mathematics is in relation to work and life. They also claimed mathematics can be fun, although they had differing opinions about whether they like mathematics, with one student stating: "If we are just repeating stuff I get a bit bored" (Year 6 student, School E). The students disliked repeating content when other students didn't understand, indicating a desire for a differentiated curriculum.

The students at School E were very clear about their likes and dislikes in relation to mathematics lessons. One student said: "I like using my brain more than my pen", explaining that rather than writing all the time, he preferred a more hands-on approach to learning and also indicated that he enjoys problem solving. The students also talked about their dislike of specific mathematics topics such as multiplication, fractions, and 24-hour time.

Prior to using Matific the students had used minimal technology in their mathematics lessons. Like the students at other schools in this project, their teachers mainly used technology via an IWB to demonstrate, model concepts and view the occasional website.

Using Matific

As a result of previous work and identified student needs, Lachlan and Kerry designed and implemented a unit of work based on the Number and Algebra strands, focusing on the four operations and order of operations. The unit spanned five weeks and consisted of ten lessons, including the administration of a post-test. The following Matific resources were included in the unit activities:

- A Balancing Act (Levels 1 – 3)
- Feed the Lions
- Ask a Monster
- Got to Split
- Somewhere Along the Line
- Four Operations Game
- Order of Operations Decimal

- Order of Operations Expert
- Order of Operations Parentheses

Lachlan and Kerry integrated the Matific resources into their teaching in a variety of ways. They selected the *Ask the Monster* episode to use as a model during the introduction phase of several of their lessons. This was because the episode was problem solving based and included several of the concepts being covered in the unit. The students then used Matific towards the end of each lesson and as homework tasks.

Both Kerry and Lachlan took advantage of the full functionality of Matific. They differentiated the tasks to suit the abilities of individual students, and used the reporting function of Matific to track students' progress in class and at home. This meant that both teachers used the students' Matific results as assessment data. Kerry made this comment about Matific's functionality:

> *It was perfect in a sense that we made it a point that we started at the middle and we went down for those who needed extra support, which was fabulous because they were still doing it visually, they were doing the exact same thing, and then we also gave the option that they could go up if they felt confident enough but at the same time visually, it was exactly the same for those kids that don't want to be different, that maybe do need that little bit of extra support (Lachlan, Year 6 teacher, School E).*

On commencement of using Matific the students attempted to use small XO laptops however due to technical difficulties they then moved to using the computers available in the secondary classrooms at the school.

Students' Perceptions of Matific

When asked about their experiences with Matific, the students in the focus group were overwhelmingly positive, which may be attributed to the way the resources were integrated into the teaching and learning. Evidence of the students' increased engagement as a result of Matific was their reaction to losing access to the resources due to a subscription issue. The students were quite upset, saying they had been 'kicked out' of Matific. Fortunately, this was rectified following the focus group meeting and the students regained their access.

The increase in the use of technology within their mathematics lessons was also a contributing factor to the improvement in engagement. One student said: "I think it is fun because it is mixed into a game and it is also maths and it is easier to learn how to do everything", while another said: "I think people like maths a lot more now since they got the chance to go on the computers". Beyond the novelty of using technology, there was an awareness amongst the students that learning was happening. They liked the gradual increase in difficulty within each episode and they also noticed that: "The questions are randomised. You can't copy it" (Year 6 student, School E).

The use of Matific appeared to promote perseverance amongst the participating students at School E. This comment was a typical one: “well the first time when we tried it I didn’t know whether...I kept on getting it wrong...kept on going back and back and I finally got five stars” (Year 6 student, School E). The students were also aware that their teachers were tracking their achievement on Matific, and although this made them feel slightly nervous, it also made them want to try harder:

> *People don’t think it is maths, they think it is like a game with a bit of maths involved. So that makes them work harder and it is a lot better than just writing it down on paper and working it out (Year 6 student, School E).*

All the students at School E wanted to continue using Matific in their mathematics lessons and homework, stating they were excited to do maths and that: “it (Matific) is awesome” (Year 6 student, School E).

Teachers’ Perceptions of Matific

Both Kerry and Lachlan were as enthusiastic about Matific as their students. Although they initially experienced some technical issues with logging on and some lag, this was sorted out and the experience was positive.

> *Most of the things that the children were given to an extent were self-explanatory but at the same time if they needed that little bit of extra guidance it was there as well. Which made it fabulous for those kids who wanted to move ahead but it meant that you were able to support those ones that needed a little bit of extra support. It was fabulous (Kerry, Year 6 teacher, School E).*

Because the teachers used every aspect of Matific they were able provide comments on a range of affordances. For example, Kerry spoke about the reward system and how it incorporated visual, sound and language rewards, saying: “It hit the mark in lots of different ways of feeding back to the kids” (Kerry, Year 6 teacher, School E).

Lachlan talked about the ability to track the students and how it assisted Kerry and him:

> *It was a progression and you could see then – the ones that struggled they may have had to do the same activity once or twice to get a hold of it, but then they could get to the next...So in that way, it was a good progression and it suited all the kids. So there wasn’t anyone that said ‘I can’t do this’ or ‘this is too hard’ (Lachlan, Year 6 teacher, School E).*

The teachers believed the use of Matific promoted mathematical discussion, perseverance, and ‘collective encouragement’, saying: “They would challenge themselves but also challenge each other, it was very good” (Lachlan, Year 6 teacher, School E). Another feature of Matific that the teachers found positive was the opportunity for all students to achieve success as a result of having the tasks differentiated: “Every activity they did gave them some level of success at some stage” (Lachlan, Year 6 teacher). Being able to experience

success is an important element of student engagement, and plays a significant role in building confidence and a positive attitude towards mathematics.

The teachers also talked about how the students enjoyed having homework that incorporated Matific:

> *They liked it. For some who don't have a computer or internet at home, we have a study centre every Tuesday and Wednesday. They would actually come here at 8:00 o'clock to go down to the computers to do their homework. So there were kids lining up at Study Centre. And they can also go to the library during lunch time so they would miss their lunch time play or morning play to go and do their homework just to have it done. So that way it showed how engaged they were by it, that they wanted to go and do their homework (Lachlan, Year 6 teacher).*

Lachlan and Kerry found that Matific had an influence on their students in many ways. There was evidence in the post-tests that students had applied specific concepts they had learned within Matific episodes, with Lachlan describing what occurred in this comment:

> *He even used that when he was doing his paper test, he did the little drawings so there were a few of the whole group that actually did – we called it the Matific craze! And they actually drew that diagram that they had used on the program (Lachlan, Year 6 teacher, School E).*

Matific was also helpful in addressing the needs of some students who had learning disabilities. When comparing Matific to other digital mathematics resources they had used in the past, Lachlan said this:

> *I would say it is probably one of the best ones I have used. I have used Mathletics, it was quite good but not as good as this one because it was more gamey and the kids had seen it as a novelty rather than a learning tool. Where this one was seen more as a learning tool rather than a novelty (Lachlan, Year 6 teacher, School E).*

Kerry talked about using Study Ladder in the past, but found the level of difficulty jumped from being very easy to quite difficult. She also made this comment about Matific:

> *I think the ease, the interface is much nicer, for the teacher the ability just to drag and drop – there's your activity, right off you go. And when you are in the middle of the lesson and something else pops up and you see something else and you drag and drop it and they get it instantly as well. Like there is not that – now you need to log off, or log back on, or reset – like it is just there. Yeah the system is fabulous for that.*

Both teachers were enthusiastic about continuing the use of Matific into the future.

Engagement with Mathematics

It is clear that the students at School E were highly engaged with mathematics as a result of using Matific. Kerry made this comment that synthesised the general consensus:

So it was absolutely brilliant. It was very, very engaging for the kids. They found it – and I found it as well – they were learning from their mistakes based on the feedback that they were getting instantly from the program itself which was really good I found. And they wanted to know ... They really got a lot out of it which was fabulous and it was such an easy program to use. It wasn't cumbersome (Kerry, Year 6 teacher, School E).

Both teachers spoke in great detail how the use of Matific had engaged their students on cognitive, operative and affective levels, addressing many aspects of the FEM. When talking about the cognitive challenge embedded within each episode, Kerry said:

It really challenged those higher order thinking kids but at the same time it was still challenging enough but at a level that the children who struggled a little bit were still able to give it a go and even if they made a mistake it was a mistake that was able to be guided, it was challenging cognitively for both levels which was great (Kerry, Year 6 teacher, School E).

Although it could be argued that the novelty of using digital resources may have been a significant contributor to the increase in student engagement, Lachlan claimed that novelty was only one factor: "They were engaged by it...they could see that it was meaningful, that they were learning something" (Lachlan, Year 6 teacher, School E).

In addition to improving student engagement, it appears that the use of Matific increased the teachers' engagement with the teaching of mathematics, and this contributed to the success of the project at School E.

Academic Results

The pre-test comprised 19 questions that required students to make estimates to calculations, perform multiplication and division of numbers, use order of operations and insert grouping symbols. The post-test used the same questions as the pre-test with the numbers changed. Both classes completed the same tests. The results are summarised in the Table 7. Copies of the pre and post tests are in Appendix 12.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Kerry	46%	64%	32%	Student A: 44% to 20%
Lachlan	43%	72%	43%	none

Table 7: School E Results

Kerry

The students in Kerry's Year 6 class scored an average mark of 46% on the pre-test and an average score of 64% on the post test. This shows improvement in students' understanding. Kerry stated "the pre-test showed that we really need to work on estimation." The improvement index for that class was 32% which indicates that there was significant growth in students' understanding. However, one student had a significant decrease in

performance from 44% to 20%, which indicates that this student would need further assistance.

Lachlan

The students in Lachlan's Year 6 class scored an average mark of 43% on the pre-test and an average score of 72% on the post-test. While Lachlan did not use the pre-test to assign Matific episodes to particular students he did make changes based on their performance on the Matific episodes. "Some stages we had them split if we had seen they were struggling the day before or the activity before" (Lachlan Year 6 teacher, School E). The improvement index was 43% indicating significant growth.

School F

School F is situated in an average socio-economic suburb just outside Newcastle to the north of Sydney. It is a small school with a total cohort from kindergarten to year 6 of 152 students. The school has a multicultural population with about 40% of students coming from a home where English is the second language. The NAPLAN results in Year 5 indicate that this school usually performs below the state average in numeracy. At this school the participating students were from a Year 5 and a Year 6 class. Both of their teachers, Alana (Year 5) and Deena (Year 6), had over ten years of teaching experience. The school has a small number of iPads for classroom use as well as a shared computer lab within the school library, set up with desktop computers.

Students' Attitudes to Mathematics Prior to using Matific

When discussing their perceptions of mathematics prior to using Matific, the Year 5 students at School F had mixed attitudes towards mathematics. Some liked some aspects but not others, and some felt it was boring. The students talked about operations with large numbers and fractions being a difficult aspect of mathematics. Interestingly, when asked about the importance of mathematics, the students did not talk about real life applications. Rather, they discussed how it is important to learn mathematics for future employment. Their use of technology was limited to a program called Study Ladder when they attended the computer room. There was no use of iPads or laptops within the classroom.

When discussing their perceptions of mathematics, the Year 6 students were quite positive but not over enthusiastic. "I think maths is alright but I wouldn't really do it 24/7" (Year 6 student, School F). They spoke about the importance of mathematics in obtaining employment and the use of mathematics in the real world. Fractions, decimals and percentages were areas of concern. Their use of technology was similar to Year 5 as they attended the computer room two or three times a week for all learning areas and rarely for mathematics.

Using Matific

The teachers designed a unit of work based on the Fractions and Decimals sub-strand, specifically exploring the conversions of fractions and decimals and calculations involving multiplying and dividing decimals (Appendix 13). The topic was selected as it had been identified from previous assessment tasks as an area of need. The following Matific episodes were selected for use within the unit:

- Maths games spinning numbers
- Feed the Lions - multiply multiples of 10
- A Half-Baked Idea – tables
- Bricks and Tables – ratios and sequences
- One in a Hundredth
- Weighing Matters – round decimals

- Fraction to Decimal – 2 decimal places
- A Ballpark Estimate – multiplication 2 decimal places
- Monster Shop – add decimals level 1
- Monster Shop – add decimals level 1

The unit of work spanned eleven mathematics lessons. Both of the teachers incorporated the Matific resources in the same ways. They each completed some explicit teaching first and then split the class into two or three groups depending on the activity and one group worked on the computers in the computer room using Matific. Alana did not differentiate the Matific activities but had all children start at the same level and work up the levels as far as they could. "I had some levelled ones for the students to do but I let everyone do them so they can gradually move up a level. If they couldn't go up to the hardest [level] that was fine" (Alana year 5 teacher, School F).

Deena used two groups, one working on the computers and the other completing written activities. As with Alana she did not differentiate the activities but allocated all episodes to all students. "They all did them all, but there were some that more children – well, they were all set them all, but some of the lower children didn't get to all of them. So, I put them in an order, and I said you've got to do this one first, and then that one, and then that one" (Deena year 6 teacher, School F).

Neither teacher set Matific episodes for homework. While Alana did not provide a reason, Deena explained: "My class don't have enough access to the internet at home as a whole, so I didn't think it was equitable to get them to do that" (Deena year 6 teacher, School F).

The reporting option in Matific was not used by either teacher. While Alana did not use it she commented that she may use it with individual students: "I probably wouldn't do that with the whole class. I might do it individually". This view was shared by Deena: "…as long as they only see their own and they can't compare themselves to anybody else".

Students' Perceptions of Matific

Following the unit of work, the students participated in their second focus group discussion. There was a clear shift in the focus of their discussions when compared to their initial focus group. More students displayed positive attitudes, and they were much more animated when talking about mathematics. They spoke specifically about aspects of the fractions and decimals unit and the role Matific played in their learning. "So we've been weighing on the computer, it's like converting fractions into decimals and converting decimals into fractions" (Year 6 Student, School F).

When discussing technology, and Matific specifically, there was a very strong emphasis on the advantages of using Matific over pen and paper exercises. "I think it helps me better than the paper, because you can interact with it and you can visually see what you're doing"

(Year 6 student, School F). Almost every student spoke about the benefits of the 'hands on' aspect of Matific over written exercises and the benefits of the instant feedback and the 'teaching' aspect of Matific. "Well it would like tell me it's wrong, and then it would like give an example and stuff like that, and I would try again on a different one." (Year 6 student, School F).

The students in both classes spoke clearly about how Matific helped them to learn: "I think Matific has helped me learn a lot and the programs, they helped me a get lot better in fractions and decimals" (Year 5 Student, School F). The instant feedback aspect of Matific was beneficial to many students, with one student saying "I learnt from my mistakes" (Year 6 Student, School F). The real life aspect of Matific also appealed to many of the students: "I think it's really good because it can help you to learn strategies to deal with real life problems" (Year 5 student, School F).

Some students described difficulties in understanding the questions and the operation or manipulation of some episodes and this aligns with the teachers at times demonstrating some Matific episodes before the students attempted them: "It makes questions a little bit confusing for me" (Year 5 student, School F). Another student commented: "That one was confusing for me at first but at points the teacher did need to explain some of it but once I got the hang of it I thought they were really fun" (Year 6 Student, School F).

Teachers' Perceptions of Matific

Alana and Deena had similar responses to Matific and they incorporated the episodes into their teaching in very similar ways. They both allocated all of the episodes to every student and did not differentiate: "They all started on the same place and they gradually went up" (Alana, Year 5 teacher, School F). They felt that this was a fairer way to have the students access the episodes. Students were not expected to necessarily complete all of the episodes but were encouraged to complete as many as possible. Deena said: "I was happy for those who could to go on and do the others, but I wanted them - I did have a big talk to them first about how it wasn't just a game. You're supposed to be learning something" (Deena, Year 6 teacher, School F).

Each of the teachers had some experience with other digital resources, in particular *Study Ladder.* However, they were both positive about their experiences with Matific and indicated they were planning on continuing its use. Alana went on the say: "I mean there is more content too in Matific compared to *Study Ladder*" (Alana, Year 5 teacher, School F).

Both teachers felt that demonstrating some of the Matific episodes before the students attempted them was beneficial and that sometimes the actual way in which the episode worked required some demonstration beforehand.

> *I found that with some of them, it was more – of more value to the children if I showed them on the smart board first and we did one together, and then they went off and did it on their own. I'm thinking specifically of one to do with measuring decimals that had*

scales and there was one part of the activity where the children had to weigh one thing, weigh another thing and work out the difference between the two by adding weight to one side until they were equal (Deena, Year 6 teacher, School F).

Concept development was an important aspect of incorporating Matific episodes into their teaching and both teachers emphasised with the students the importance of playing the games to learn the mathematical concepts. While they did some explicit teaching, the Matific episodes were used to consolidate and enhance the development of the concept. Alana stated: "Because it wasn't just me up there teaching. They were actually like physically playing the game to grasp the concept" (Alana, Year 5 teacher, School F). The challenge provided by Matific episodes was important for Deena and her students in the development of concepts: "I think too, because there was an element of challenge to some of those activities that they haven't had in other maths games they play" (Deena, Year 6 teacher, School F).

While the Matific resources have not changed the way in which Deena teaches she is convinced that they will definitely add to her teaching and be a useful resource: "I always try to get up to the computer lab at least a couple of lessons a week so that they can all have a turn at doing something different, so, they've (Matific) added to it" (Deena, Year 6 teacher, School F). Alana would like to incorporate Matific episodes into all of her teaching whenever possible: "…when we're in the computer lab I will set them some tasks to do with the strand that I have been teaching. That way we can make sure that the students complete them which I'm sure they will" (Alana, Year 5 teacher, School F).

Engagement with Mathematics

Both teachers at School F noticed significant changes in student engagement during their use of Matific. While they had used another mathematics program the students preferred Matific. When comparing Matific with the other program Alana commented: "I think Matific is a lot more engaging for the students". And she went on the say: "No they were really engaged – they absolutely loved it. They really loved doing maths this way. It's a great tool too" (Alana, Year 5 teacher, School F). Deena felt that the other maths program was very monotonous and predictable and that is why she did not use it any more.

When discussing the Year 6 students in the computer lab working on Matific episodes Deena commented: "They were really engaged by them, which is good – usually computer lab time's very noisy but they were very quiet and on task, so that was good" (Deena, Year 6 teacher, School F). She went on to comment: "…and they did really enjoy the Matific, I had a lot of them that said to me that it is the coolest Maths program we've done" (Deena, Year 6 teacher, School F).

The teachers' beliefs that Matific improved their students' engagement is reflected in the students' focus group discussions, with this quote a typical one:

I think it's a good program. It helps you learn and it does it in a fun way so to move things around on it and showing you how to do it. There was this one you had to feed the animals and there were actual objects on the thing (Year 5 student, School F).

Academic Results

The pre-test comprised 26 questions that required students to convert between fractions and decimals, order decimals, perform multiplication and division questions involving decimal and solve worded problems. The post-test used the same questions as the pre-test with the numbers changed. Both classes completed the same tests. The results are summarised in the Table 8 and copies of the pre and post tests are in Appendix 14.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Alana	28%	57%	40%	none
Deena	44%	74%	54%	none

Table 8: School F Results

Alana

The students in Alana's Year 5 class scored an average mark of 28% on the pre-test and an average score of 57% on the post test. This shows improvement in students' understanding. When considering the pre-test results Alana stated "Because they're Year 5 and we've gone into decimals and decimal places and all that sort of thing I've really had to start from the beginning" (Alana, Year 5 teacher, School F). The improvement index for that class was 40% which indicates that there was significant growth in students understanding. No students had a significant decrease in their performance.

Deena

The students in Deena's Year 6 class scored an average mark of 44% on the pre-test and an average score of 74% on the post-test. This demonstrates the large differences in ability between classes and is indicative of children at such a young age. The improvement index was 54% indicating significant growth. While Deena used the pre-test data to focus on particular aspects of decimals and fractions she did not differentiate the Matific episodes. Later, Deena stated:" there wasn't kind of one area that I could tell the whole class was weak in this. I need to focus on it...so I just started at the beginning" (Deena, Year 6 teacher).

School G

School G is situated in a low socio-economic are of south-western Sydney. The school is well equipped with a modern library, hall, technology room, newly refurbished and computer-networked classrooms, an interconnected classroom and all classes have electronic smartboards. School G has a large multicultural population of 383 students, with 75% from language backgrounds other than English. According to the MySchools website, the school's NAPLAN scores in numeracy were slightly above the state average. The two participating teachers, Caitlyn and Sharon, were highly experienced teachers. Caitlyn taught a composite class consisting of students in Years 5 and 6, and Sharon's class consisted of Year 6 students.

Students' Attitudes to Mathematics Prior to using Matific

The focus group students at School G had mixed attitudes towards mathematics that included feelings of negativity and anxiety. Some were able to discuss why mathematics is important in terms of real life, while others only saw mathematics in relation to school and homework. The general consensus was that mathematics is challenging, with one student stating: "I think maths is challenging because sometimes I get caught up the work and I don't know the answers" (Year 6 student, School G), and another saying she doesn't like mathematics when "I don't know the questions and I'm getting really confused and get a bit angry" (Year 5 student, School G).

The students' comments about mathematics implied that they were currently experiencing a traditional teaching approach that incorporated a heavy reliance on worksheets and on the memorisation of facts, which can lead to negative attitudes and disengagement. One student from Caitlyn's class made this comment about his teacher: "She keeps on repeating the same things over and over again to help us learn and keep it in our minds so we don't forget it" (Year 6 student, School G). This type of repetition may not assist in resolving misconceptions that may be the cause of students forgetting facts or concepts.

The students at School G indicated there was little to no use of technology in mathematics lessons prior to the Matific project.

Using Matific

Caitlyn and Sharon designed a unit of work on angles as this was the next topic to be covered according to their scope and sequence document (Appendix 15). The unit spanned two mathematics lessons and although a range of Matific episodes were listed in the resources required for the unit, the teachers did not document how they were to be integrated into the teaching and learning activities within the unit. The episodes listed were:

- Know all the Angles
- Adding and Subtracting Angles
- Parts of a Circle
- What's Your Angle?
- Protractor: Angles of Triangles Level 1

When asked about how she incorporated Matific, Caitlyn stated that she used the activities once students had completed the planned classroom activities. When Sharon was asked how she incorporated Matific she only spoke about how she had used some addition episodes in her teaching (separate to the unit on angles). Neither teacher set Matific for homework as the school had a policy of not setting homework, and neither teacher used the pre-test data to differentiate the episodes to meet student needs. Matific's function of being able to track student achievement was not accessed by the teachers at School G.

Both teachers had their students accessing Matific on iPads during group activities as there weren't enough devices for each student to work individually. Caitlyn's students also used computers to access Matific.

Students' Perceptions of Matific

When discussing their mathematics lessons following the unit of work on angles, the students showed some signs of improved engagement and indicated they enjoyed using technology to learn mathematics. One student made this comment: "I think I knew more when we were doing it on the computer than I would have doing it in my book" (Year 6 student, School G). The students felt that the Matific episodes provided challenge, which in turn made the mathematics more fun and enabled them to learn: "Using a protractor was fun and I didn't know how to use it (before)" (Year 6 student, School G).

The students made many comments about the mathematics content they had learned during their use of Matific and this was a typical comment: "I didn't know what the angle names were called or what bits of the angles were called so now I know" (Year 5 student, School G). As with other students at other schools, these children appeared to have improved their perseverance with tasks due to the Matific reward system. One girl who was struggling with mathematics said: "I keep on practicing. I keep on doing it again" (Year 6 student, School G). It is interesting to note that the word 'practicing' was used rather than 'repeating', indicating the development of a positive mindset towards mathematics.

During one of Sharon's lessons she inadvertently displayed her results screen on the IWB. The students saw their results and rather than having a negative effect, seeing their results encouraged the students to work harder to improve their scores. One student made this comment: "It made me want to do it all over again" (Year 6 student).

Although the students did not have to complete homework, several did access Matific at home because they had enjoyed using it at school. One student who had used it said he had shown his parents what he was doing, adding: "It is fun, fantastic". When asked if they would have liked to use Matific at home, another student said:

> *Yes, I think I would have. I would have used it to make my strategies improve, so that I would get more A's and more Aces and so that I can get a good report and go to a good university and all (Year 6 student, School G).*

Teachers' Perceptions of Matific

Sharon and Caitlyn's perceptions of Matific and their students' reactions to it did not completely align with the students' perceptions. Although the students were quite positive about their experiences and felt they had learnt a lot from using Matific, Sharon and Caitlyn's comments indicated a lack of awareness of the students' perceptions.

Sharon indicated her students had loved the episodes, saying: "It was really easy for them to know what they had to do" (Sharon, Year 6 teacher, School G). Sharon didn't use the IWB to demonstrate how to use the episodes and, as stated earlier, she did not track student progress using Matific. She commented that students: "were pretty much just on task", implying that there was no evidence of enthusiasm, and her own focus may have been on monitoring behaviour rather than student learning.

Sharon made the following comment in relation to the Matific episode content: "I had to actually do a lot of teaching, they didn't know how to use a protractor" (Sharon, Year 6 teacher, School G). It appears that Sharon's expectations of Matific may not have matched the intention of Matific episodes, and perhaps she did not actually engage with the episodes prior to letting her students access them to ensure they had the appropriate prior knowledge. Sharon was also unaware that her students believed Matific had taught them how to use a protractor.

Sharon felt that the use of Matific did not promote mathematical discussion, although this may be the result of classroom culture. She appeared to be unaware of the curriculum requirements in relation to Working Mathematically and the Communicating and Reasoning components that are difficult to address without dialogue. The FEM also cites continuous communication as an important factor to promote student engagement.

In Caitlyn's classroom things were more positive. Caitlyn believed one of the biggest benefits of Matific was the instant feedback for students, making them more independent. She made this comment:

> *I noticed yesterday when they were working on it even with the kids that I know I have to spend a lot of time with because they disengage very quickly if I am not with them. And we didn't have that issue because they were on it. If they had a problem, they would put their hand up but I didn't have to sit with them (Caitlyn, Year 5/6 teacher, School G).*

In terms of mathematical content, Caitlyn was surprised that her students had learned concepts beyond her expectations. This was an interesting observation as it indicates that, similarly to Sharon, Caitlyn did not thoroughly explore the selected Matific episodes prior to using them with her students. Had she known what was in the Matific episodes, she may not have been surprised that her students had learned new concepts.

Caitlyn believed Matific promoted high levels of collaboration amongst her students, however this may not necessarily have addressed the requirements of the Working Mathematically curriculum strand as it appears most of the work in Caitlyn's classroom is completed on an individual level.

Caitlyn made some general comments about using Matific in the future, stating she would be willing to use it again: "We have been looking for something like this as a tool because that is what we are missing" (Caitlyn, Year 5/6 teacher, School G). She spoke about the time that teachers spend looking for appropriate digital resources, saying:

> *...that is where a lot of our teachers I think are wasting valuable time because they sit there for hours researching and I look at Matific ... teachers can use it that way as an introduction or throughout (a lesson) or they can use it at the end (of a lesson), whichever way – there are different ways that you can use it - I really like it in that sense (Caitlyn, Year 5/6 teacher, School G).*

Engagement with Mathematics

Although there appeared to be a mismatch between the teachers' and students' perceptions of Matific, the data indicates an improvement in students' engagement due to their use of Matific. There is evidence that Matific provided cognitive, affective and operative engagement. Comments such as this from Caitlyn support this claim: "I had a few of them really excited when they got awesome or up to the next level" and "To me they were super keen in getting better, they just wanted to improve". In addition, students accessed Matific from home, which was not a homework requirement. On the other hand, Sharon admitted she has a fear of technology and has difficulty engaging her students with mathematics so perhaps her challenges would have been the same, regardless of the digital tools being used.

Comments from the students strengthen the case that engagement improved. The following comment indicates a combination of affective and cognitive engagement: "I think it has been more than fun. I think it (the learning) has definitely sunken into me" (Year 6 student, School G).

Academic Results

The pre-test comprised 17 questions that required students to name types of angles, measure angles using a protractor, and construct angles of a specific measure using a protractor. The post-test was exactly the same as the pre-test. Both classes completed the same tests. The results are summarised in Table 9 and copies of the pre- and post-tests are in Appendix 16.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Sharon	28%	67%	53%	none
Caitlyn	38%	66%	53%	Student A: 55% to 40% Student B: 70% to 44% Student C: 75% to 40% Student D: 73% to 30%

Table 9: School G Results

Sharon

The students in Sharon's year 6 class scored an average mark of 28% on the pre-test and an average score of 67% on the post test. This shows improvement in students' understanding. When discussing the pre-test Sharon stated: "I loved that idea of the pre-test. So we used the same test, the pre-test and … and every single person improved. Um, yeah basically they knew nothing about angles" (Sharon, Year 6 teacher, School G). The improvement index for that class was 53% which indicates that there was significant growth in students' understanding. No students had a significant decrease in their performance.

Caitlyn

The students in Caitlyn's year 5/6 class scored an average mark of 38% on the pre-test and an average score of 66% on the post-test. This shows that while the students already had a low level of understanding before the unit was presented and there was significant improvement in students' understanding as a result of the unit. The improvement index was 46% indicating significant growth. Caitlyn use the pre-test results to determine what she needed to teach considering that the class was composite Year 5 and 6. "So that helped me because I thought well instead of trying to do them both I can just concentrate at this level" (Caitlyn, Year 5/6 teacher, School G).

School H

School H, situated in a high socio-economic area of Sydney, is a government K-6 school where students generally achieve high academic outcomes. The school has two Opportunity Classes (a class for gifted and talented students) and it achieves above average results in NAPLAN. The participating students in this evaluation were two Year 6 classes. Both Year 6 teachers Chelsea and Donna have many years of teaching experience. The school allocates a small number of iPads and laptop computers to each class. The Year 6 classes have four iPads and three laptops each. Each class has access to the computer lab for one hour per week.

Students' Attitudes to Mathematics Prior to using Matific

When discussing their perceptions of mathematics prior to using Matific, the Year 6 students at School H had mixed attitudes towards mathematics. Some loved mathematics, found it interesting and enjoyed the challenge it provided while others said that they hated it. Interestingly, all of the students interviewed expressed that mathematics was important for their future in the workforce, and at university. Some of the students expressed concern about the amount of testing in mathematics and the pressure associated with their performance in the tests. Some felt the grouping into ability level mathematics groups increased the pressure to perform as those in the lower group were seen to be not as smart as those in the higher group.

The use of technology in mathematics was very limited, and the only example the students were able to provide was Mathletics, which was set for homework on a regular basis: "most of the time it's just worksheets" (Year 6 student, School H). Some students commented that there was too great a focus on worksheets and that the completion of these was at times boring and that it affects their engagement: "If I sit there doing the same booklet or worksheet for more than 20 minutes I get really irritated and I get off track and I don't concentrate as well" (Year 6 student, School H).

Using Matific

The teachers designed a unit of work based on the Number and Algebra substrand specifically exploring fractions in different representations and the addition and subtraction of fractions. Although the teachers designed a unit together, they chose to complete separate documentation, and both those units are presented in Appendix 17. The topic was selected as it had been identified from previous assessment tasks as an area of need and it was the next topic in the scope and sequence. The following Matific episodes were selected for use within the unit:

- The monsters share
- Birds on the Wire 1, 2, and 3
- Pizza toppings 1 and 2

- Say cheese 1 and 2
- Hang the fractions
- Along the same line
- Comparing fractions
- All the same to me 1 and 2
- Adding and subtracting fractions-playlist
- Adding and subtracting mixed numerals-playlist
- Pour yourself into it 1, 2, and 3.

The unit of work spanned three weeks. Each of the teachers incorporated the Matific resources in different ways. Chelsea differentiated the Matific episodes but the students chose to do other episodes as well or instead of those assigned. Chelsea utilised the laptops in the classroom and not the weekly class visits to the school computer lab and this meant Matific was often used separately to her classroom mathematics lessons: "…it wasn't always on the same day. So we would do that concept first and then once I was happy with what they were doing then we would do it on Matific". She chose to teach the concepts first and use Matific as consolidation: "I would like to use it for consolidating…but I probably would give it more for homework". It appears that a number of students in Chelsea's class were only given the opportunity to do one or two Matific episodes.

Donna separated her class into three groups and assigned specific Matific episodes to each group based on their level of performance in the pre-test. She used the laptops in her room and borrowed others but did not use the computer room to access the Matific episodes. Although she had access to the use of some iPads, she opted to use the laptop computers for this reason:

> *Our biggest problem was the iPad, we have a few problems with the apps at the moment getting it down. And so when we first started with Matific – because I only have three laptops in my room and four iPads, which I've tried to borrow from people, so this morning I managed to borrow another three laptops. But when you go onto the Matific website it doesn't quite work on the iPad (Donna, Year 6 teacher, School H).*

Students' Perceptions of Matific

The students in both classes generally liked the Matific episodes and were able to discuss specific episodes that they had completed. Initially a number of students expressed their dislike for mathematics but following the use of Matific in the fractions unit all of the students were positive about the Matific resources. Some commented that it assisted in their learning and while they do not now love maths they do not hate it as much:

> *When Miss says some people are going to be using Matific it makes me look forward to maths now. Before because generally we always have maths straight after recess so I always hate when recess ends and we have to go and do maths, but now I'm nearly*

looking forward to it because the thought of getting to go on Matific is 'yes'! (Year 6 student, School H).

Students from both classes expressed that Matific was a fun way to learn mathematics: "It's actually a really enjoyable activity. It's done in a fun way" (Year 6 student, School H). They could see that while they were playing a game they were actually learning mathematical concepts: "I think with Matific it gave me some extra help that I needed" (Year 6 student, School H). They appreciated the way in which Matific provided them with three opportunities to answer the question and then if still unsuccessful Matific explains the method of doing the question: "I like Matific where if you get it wrong it says it's wrong, try again. And then it shows you after three times and you don't have to click on a question mark or whatever. It shows you automatically" (Year 6 Student, School H).

The reward system built into the Matific episodes was a feature mentioned by students at School H. The star system and accompanying fireworks and accolades such as 'super awesome' promoted perseverance amongst the students, who were motivated to continue trying each episode until they achieved five correct answers, with one student commenting: "And I get really put off when I get something wrong and then I get really put off because I like getting 100% in everything. So I had to go back and then do it again" (Year 6 Student, School H).

Finally, students from Donna's class had a suggestion to the Matific designers asking for more challenge or further extension activities in the episodes: "I think that I would really like if they had an area where the episode was going into deeper depth" (Year 6 Student, School H). A student from Chelsea's class wanted an option to click and drop rather than drag to complete some activities: "I hate when you have to drag things because I also did that thing where you had to drag it on the line. I hate that because my fingers, they cramp and I hate that" (Year 6 student, School H).

Teachers' Perceptions of Matific

Chelsea and Donna had similar responses to Matific although they incorporated the episodes into their teaching in slightly different ways. Each of the teachers had experience with *Mathletics,* but they were both positive about their experiences with Matific and indicated they were planning on continuing its use. "Well the kids don't like Mathletics. I think they've just used it so many times they're bored with it" (Chelsea, Year 6 teacher, School H). The issue of resources seemed to be a limiting factor in the use of Matific:

So I definitely am going to use it and continue to use it as a tool, but I also think it's just hard with my resources. If I was able to get enough laptops all the time I definitely would use it more (Donna, Year 6 teacher, School H).

Both of the teachers used the feedback aspects of Matific in a limited manner and commented that perhaps they should have used it more: "…I would love to have a date when they had done those. I never found when they had actually completed them"

(Chelsea, Year 6 teacher, School H). Donna found it difficult to use effectively: "…look at the results of Matific and how they all were going, but I didn't quite – I kept having a look, I didn't quite find it as easy to use" (Donna, Year 6 teacher, School H).

Both teachers were able to locate episodes that targeted specific areas within the unit of work but commented that they would like a grading system that suggests the next episode and the previous episode so that they could grade more easily:

> *It would be great if the Matific could give me the actual ones to do rather than me having to search through everyone and look at them and check and see which ones would be specific (Chelsea, Year 6 teacher, School H).*

Chelsea's final comment was: "I wish I'd used Matific more than what I did. I felt like I struggled with time and we don't have so many computers".

Engagement with Mathematics

Both teachers at School H noticed significant changes in student engagement during their use of Matific. Donna talked about how the students liked using the Matific episodes and that some of them were able to progress really quickly and effectively while some of the struggling students needed multiple attempts at some episodes. This could have been due to the way in which she allocated the episodes to particular groups of students. However, according to Donna, despite the limited availability of laptops the students all seemed to enjoy doing the episodes: "Most of them really were happy to do it, and in fact this morning I got them all – a lot of them to do it again and they were all excited to be doing it" (Donna, Year 6 teacher, School H).

Chelsea talked about how most of her students enjoyed using Matific and although some didn't like it they all appeared to be engaged when they were completing the episodes. The issue raised by Donna with respect to the access to laptops was an issue for Chelsea as well: "I did struggle to find the time to have them all on it because we're always time poor. When they did get on, yes I think they were engaged" (Chelsea, Year 6 teacher, School H). The teachers' beliefs that Matific improved their students' engagement is reflected in the students' focus group discussions, with this quote a typical one: "For Matific I like it because it's like fun and it's educational at the same time" (Year 6 student, School H).

Academic Results

The pre-test comprised 22 questions, for a total of 50 marks, that required students to order fractions on a number line, calculate equivalent fractions and mixed numbers add and subtract fractions and solve worded fraction problems. The post-test comprised ten questions, for a total of 25 marks, and used very similar questions to the pre-test with some of the numbers changed. Both classes completed the same tests. The results are summarised in Table 10 and copies of the pre and post tests are in appendix 18.

Teacher	Pre-test average	Post-test average	Improvement Index	Children with a decrease of 10% or more.
Chelsea	62%	74%	31%	Student A 36% to 16%
Donna	76%	88%	48%	none

Table 10: School H Results

Chelsea

The students in Chelsea's Year 6 class scored an average mark of 62% on the pre-test and an average score of 74% on the post-test. This shows improvement in students' understanding. The improvement index for that class was 31% which indicates that there was significant growth in students' understanding. However, one student had a significant decrease in his performance from 36% to 16%, which indicates that this student would need further assistance. The decrease could have resulted from a number of the easier questions from the pre-test being removed from the post-test but the student still did not progress following the unit of instruction. Chelsea spoke about using the pre-test to group students but she did not differentiate the use of the Matific episodes to suit the needs of individual students.

Donna

The students in Donna's Year 6 class scored an average mark of 76% on the pre-test and an average score of 88% on the post-test. This shows that while the students already had a high level of understanding before the unit was presented there was improvement in students' understanding as a result of the unit. In fact, this class began at a higher pre-test average than the other class's post-test average. This demonstrates the large differences in ability between classes and is indicative of children at such a young age. The improvement index was 48% indicating significant growth from what was originally a very high base. Later Donna spoke about using the pre-test to determine which activities would be appropriate for each individual student with the use of Matific and tailoring the selection of Matific episodes to suit the needs of the individual. For the students that displayed significant issues in the pre-test Donna spent time with them individually.

CROSS CASE ANALYSIS AND DISCUSSION

The aim of this research evaluation was to investigate the effectiveness of the Matific suite of digital mathematics resources in the primary mathematics classroom in improving student learning and enhancing students' engagement with mathematics.

The research investigated the following questions:

1. To what degree do the Matific digital mathematics resources assist primary children to understand and learn difficult mathematics content?

2. In what ways do the Matific digital resources influence student engagement with mathematics?

The following is a cross case analysis and discussion of the findings. Data from across the eight cases has been analysed and organised thematically to seek answers to the above research questions. First, themes emerging related to teaching and Matific will be discussed. Then, themes around learning and student engagement will be presented and discussed. The Framework for Engagement with Mathematics (FEM) (Attard, 2014) will be used as an analytical lens to explore the project findings.

Teaching with Matific

As would be expected, the 16 participating teachers in this study used the Matific resources in a variety of ways. This resulted in a diversity of opinions about the resources and varying levels of success in terms of student achievement and engagement. Table 11 provides a summary of the different methods of incorporation used by each of the teachers and it is clear that some teachers took advantage of Matific's affordances while others did not.

Differentiating Learning

A Matific affordance that appeared regularly in the data is the ability for teachers to assign different levels of Matific tasks to different students, allowing them to individualise learning, aligning with the following elements of the FEM:

- *tasks are positive, provide opportunity for all students to achieve a level of success and are challenging for all,*
- *the teacher is aware of each student's mathematical abilities and learning needs, and*
- *students' backgrounds and pre-existing knowledge are acknowledged and contribute to the learning of others.*

	Schools																
	A		B		C		D		E		F		G		H		
% Class improvement Index Pre- to Post-test	30	30	12	2	40	33	36	23	32	43	40	54	53	53	31	48	
Teachers / **Use of Matific Affordances**	N	J	A	E	S	L	J	D	K	L	A	D	C	S	C	D	%
Differentiated Matific use by allocating specific episodes to individual students or groups of students	✓		✓			✓			✓	✓					✓	✓	44
Allocated all episodes to all students				✓	✓		✓	✓			✓	✓	✓	✓			50
Tracked student achievement and progression	✓	✓				✓			✓	✓	✓	✓			✓	✓	56
Allowed students to view record of own &/or others' progression					✓												6
Set Matific homework (or gave students optional Matific homework)	✓	✓	✓	✓			✓		✓	✓							44
Homework episodes were the same as those used in class time		✓	✓	✓			✓										25
Homework tasks were different to those used in class time																	0
Homework tasks were a combination of familiar and new episodes	✓								✓	✓							20
Homework tasks were differentiated to individual learners	✓																6
How Matific was used within mathematics lessons																	
As a *teaching tool* on IWB to model concepts and/or to instruct students on how to use a specific episode	✓		✓	✓			✓	✓	✓	✓	✓	✓					56
As a *learning tool* to develop conceptual understanding						✓	✓										12.5
As a supplement to regular learning tasks to build *fluency*		✓			✓				✓	✓			✓	✓	✓		44
Used by individual students	✓	✓			✓	✓			✓	✓							37.5
Used collaboratively (more than one student per device)	✓						✓	✓					✓	✓			30
Devices Used																	
Desktops or Laptops		✓	✓	✓	✓	✓		✓			✓	✓			✓	✓	62
Tablets							✓										6
Combination of devices	✓								✓	✓			✓	✓			30
In class during mathematics lessons	✓															✓	12.5
In computer labs outside of timetabled mathematics lessons	✓	✓			✓			✓							✓		30
In computer labs within timetabled mathematics lessons											✓	✓					12.5

Table 11: Methods of Incorporating Matific Resources

Seven out of the 16 teachers used this affordance to differentiate the Matific episodes for students. Some of the seven used the pre-test data to inform their decisions, while others relied on their prior knowledge of students' abilities. Most of the teachers who did differentiate the tasks continued to do so throughout the teaching of the units. That is, when students required either harder or simpler tasks, they were able to adjust the episodes accordingly. The ability to acknowledge and address student needs is critical in developing positive pedagogical relationships, the foundation for student engagement with mathematics (Attard, 2014).

Some of the teachers who allocated all tasks to all students did so to provide choice for their students. This strategy can promote student engagement, as detailed in the FEM. Other teachers assumed students would complete as many episodes as they could, and the results of this on student engagement will be discussed later. In terms of improving learning, this particular strategy may have had a negative impact for some students, particularly those at School D, where some students were unsure if Matific had helped the learn.

One negative aspect of allocating all episodes to all students is the danger of students becoming bored through a lack of challenge, and this was evidenced at School D, where some students claimed the episodes were too easy. A way of addressing this issue is to provide tasks that fit within a child's Zone of Proximal Development (ZPD) (Vygotsky, 1978), where tasks incorporate an appropriate level of challenge but are still achievable. Matific does provide this opportunity with many of the topics covered. The teachers who did allocate tasks according to students' abilities found this affordance to be a very positive element of Matific's resources and they attributed this to their students' engagement.

In some schools, teachers may have assumed it was not possible to differentiate tasks because of a lack of access to computers or tablet devices. Several of the teachers wanted all students working on Matific at the same time, so their solution was to have students sharing devices, making it challenging to differentiate and even more difficult to track student progress.

Crossing the Digital Divide: Matific for Homework

Another of Matific's affordances is the ability for the teacher to set episodes as homework tasks. This was taken up by seven teachers in the project, who either set specific tasks for all students to do, or provided Matific episodes as optional homework tasks. The teachers who did set Matific as homework found it to be successful and highly engaging for their students, although there were, as would be expected, some students who did not have access to either the internet or a device. In School E, this was addressed by allowing access to the school's computers before school and during breaks.

The benefits of providing Matific episodes for homework, in schools where homework is an expectation, are significant. Students are able to practice the skills they learn at school in a more dynamic and engaging way (as compared to traditional, pen and paper based

homework tasks). They are able to share their learning with their families, promoting mathematical discussion, and can use time usually spent on digital devices playing non-educational games, learning and thus bridging the digital divide (Selwyn, Potter, & Cranmer, 2009).

Despite not setting Matific for homework, several of the teachers found that their students used Matific at home because they found it so engaging. At School B one teacher was approached by a parent who claimed her Year 3 child had memorised her login details so she could use Matific at home. At other schools the students indicated during focus group discussions that they would enjoy having Matific homework, yet it appears they did not communicate this to their teachers, nor were they asked if this was something they would like to do.

Student Voice

Many of the discussions around the use of Matific related to either an alignment with or a mismatch between teachers' intentions, beliefs and knowledge of their students, their students' experiences of Matific, their beliefs about learning, and their abilities. For example, the teachers at School E used all the data they had available to ensure students were allocated appropriately levelled Matific episodes. They adjusted and adapted their teaching and students' learning experiences according to their students' reactions to the resources. They were aware that the students were highly engaged and challenged within their ZPD. This awareness and alignment was the result of regular opportunities for student reflection. Conversely, in classrooms where students were not provided with reflection opportunities, the teachers appeared to be unaware of what their students thought about using the Matific resources and whether their students felt the resources were assisting them to learn. This was evident in more than one of the schools in this project.

Providing opportunities for students' voices to be heard is critical, and underpins many of the elements that are detailed in the FEM. The lack of student voice as an integral part of the classroom philosophy may have reduced student engagement and is potentially a missed opportunity for building a community of learners within these mathematics classrooms (Munns, 2007).

Integration into Teaching Practice

An interesting variable across the case studies was the way the teachers integrated the Matific resources into their teaching practices. Those teachers who enthusiastically took advantage of all of Matific's functionality appeared to have made more significant changes to their practices when compared to those who did not. The teachers who only accessed a minimum of Matific's affordances really did not adapt their practices. Rather, Matific appeared to be an 'add-on' to existing teaching and learning activities. It could be argued that if teachers are going to incorporate technology (and they are mandated to do this by curriculum authorities), then they should be using the technology to enhance teaching and

learning rather than substitute existing practices as detailed in the SAMR model (Puentedura, 2006).

Goos, Galbraith, Renshaw, and Geiger (2009) describe the four roles of technology in the mathematics classroom as: technology as 'master', which occurs when the technology is imposed on the teacher or its use is limited due to the individual teacher's beliefs about teaching; technology as 'servant', where the teacher is knowledgeable in terms of using the technology but its use is limited to the teacher's preferred methods; technology as 'partner', describing the use of technology in creative ways that result in improved quality of student learning; and technology as 'extension of self', occurring when the technology forms a 'natural' part of the teacher's repertoires and is used in highly creative ways. All four roles as described by Goos et al. (2009) were represented in this study. Those whose use of Matific was limited to just using the episodes at the end of a lesson or in computer lab time, with no discussion and no tracking of student progression, appeared to have less impact on their students' engagement than those who embedded it more holistically into their teaching within mathematics lessons and in student homework tasks. Despite this variance, the data shows student improvement and improved student engagement across all eight case studies.

Teachers' Perceptions of Matific

Overall, all teachers who participated in the case studies stated they would be willing to use Matific again in the future. Some of the teachers who were not as enthusiastic as others believed they had either selected a topic that wasn't well represented amongst the Matific episodes, or not well matched with the specific content they wanted to teach. Schools B and C were examples of this scenario where the topics of *time* and *mass* did not fit well. Other pressures on teachers such as time restrictions, lack of access to or limited numbers of devices, and technical issues relating to hardware and internet speed had some influence on how well Matific was incorporated into teaching and learning, and of course, influenced teachers' attitudes towards the resources. It is interesting to note that the teachers who were the least enthusiastic about using Matific appear to have conveyed their lack of enthusiasm to their students, who reflected very similar attitudes at the start of their second focus group discussions.

Teachers' perceptions of Matific also seemed to reflect their depth of pedagogical content knowledge (PCK) (Shulman, 1986), that is, the combination of content knowledge and knowledge of pedagogy, including their knowledge of the curriculum requirements to teach mathematics content as well as the processes of mathematics. These processes of problem solving, reasoning, fluency, understanding and communicating (the Working Mathematically strand in NSW and the Proficiencies in the Australian Curriculum: Mathematics), are intended to form the foundation of mathematics lessons and should feature prominently in planning documents and teaching and learning activities. However, those teachers who did not fully understand this requirement and focused purely on teaching and learning

mathematics content, had less positive experiences than teachers who did. Likewise, teachers who were unsure of the content they were teaching and how students build conceptual understandings relating to the chosen concepts developed less favourable attitudes towards Matific.

It is also interesting to note that the variances in how teachers incorporated Matific occurred both between and within schools. That is, in almost all cases, there were differences in the levels and methods of incorporation at the same school, where teachers were teaching identical units of work that they had planned collaboratively, and had the same access to devices. These differences could be attributed to teachers' technological pedagogical and content knowledge (TPACK) (Koehler & Mishra, 2009). TPACK is a framework for technology integration and teacher knowledge, incorporating technology into Shulman's construct of pedagogical content knowledge (PCK) (1986). Koehler and Mishra argue that there are three components that lie at the heart of good teaching with technology: content, pedagogy, and technology. "The interactions between and among the three components, playing out differently across diverse contexts, account for the wide variations seen in the extent and quality of educational technology integration" (Koehler & Mishra, 2009, p. 62).

Learning from Matific

One of the most significant themes emerging from the qualitative data gathered from students is that Matific assisted learning. Students from across all eight case studies talked about how the Matific episodes helped them learn mathematics and were able to talk about the mathematics they had learned, rather than focusing on the actual game-related aspects of the episodes. When using technology in the mathematics classroom there is always a risk that the learning focus will shift from the mathematics to the technology because of the distraction, the structure of the task, the novelty, or because of technical difficulties (Attard & Curry, 2012). This was not the case with the majority of students involved in the focus group discussions.

The size and structure of the Matific episodes was one factor that contributed to student learning. The students were able to focus on very specific mathematical concepts and skills, and this focus was able to be maintained because each episode consisted of only five questions. The students also noted that they were unable to 'cheat' when repeating episodes as the questions were different with each attempt. This made the students feel they were working hard (cognitive engagement) and promoted understanding as well as fluency, both aspects of the Australian Curriculum proficiencies and Working Mathematically strands.

The element of Matific that was most commonly attributed to assisting students' learning was the careful scaffolding built into each of the episodes. Vygotsky (1978) believed that when a student is within his or her ZPD for a particular task, provision of an appropriate amount of assistance (without giving the solution), or scaffolding, will allow the student to

complete the task successfully. As the student learns, the scaffolding is gradually removed until the student is able to complete the task on his or her own. Many of the students were able to recognise that Matific's scaffolding helped them to understand the mathematical concepts. Further evidence was in their comparisons to other mathematics resources, and their comments stating that the other resources jumped from being too easy to being too hard.

The quantitative data gathered from pre- and post-tests indicate that the overall Improvement Index for all schools is 34%. This means that students on an average improved by 34% of the available marks. This confirms that learning took place, however it is not possible to claim whether or how the use of Matific influenced this outcome as students would be expected to show some growth when exposed to teaching, regardless of what resources are used. The overall improvement index was calculated by combining all schools' improvement indices and calculating the average. Table 12 shows the calculations for the overall improvement index.

School	Pre-test average	Post-test average	Improvement Index	Pre to post diff	Number in class	Improvement total
A	76%	84%	30%	8%	23	690%
A	56%	71%	30%	15%	22	660%
B	38%	45%	12%	7%	29	348%
B	39%	40%	2%	1%	28	56%
C	52%	68%	33%	16%	14	462%
C	66%	81%	40%	15%	22	880%
D	36%	51%	23%	15%	23	529%
D	46%	66%	36%	20%	29	1044%
E	46%	64%	32%	18%	22	704%
E	43%	72%	43%	29%	19	817%
F	28%	57%	40%	29%	23	920%
F	44%	74%	54%	30%	21	1134%
G	28%	67%	53%	39%	22	1166%
G	38%	66%	46%	28%	24	1104%
H	62%	74%	31%	12%	27	837%
H	76%	88%	48%	12%	30	1440%
Totals	774%	1068%	553%	294%	378	12791%

Table 12: Improvement Index

Engagement and Matific

It is clear from the data gathered from students and their teachers in each of the case studies that engagement with mathematics improved as a result of using Matific. It is important to acknowledge that the majority of teachers in this project had not regularly used digital technologies in their teaching of mathematics, so the sudden introduction of a resource such as Matific would have had a novelty effect on the students involved and this

would have had some influence on their engagement. However, if we view engagement as the multidimensional construct consisting of affective, cognitive and operative domains (Attard, 2014), then the novelty of using the technology would not lead to deep, sustained engagement. Further to this, the data suggest deeper engagement did occur across each of the case studies in this project. Significant factors leading to the students becoming more engaged are the provision of instant feedback, the Matific reward system, and the level of academic challenge and scaffolding.

Feedback and Rewards

An important point of difference between Matific and other digital resources the participating students had used in the past was the fact that rather than simply state when an answer was incorrect, Matific provided assistance that promoted the development of conceptual understanding. The provision of timely feedback on student work is important for student learning and engagement (Attard, 2011). The FEM states that positive pedagogical relationships exist when *feedback to students is constructive, purposeful and timely.* The immediate feedback provided from digital technology has already featured in literature as an affordance that improves student engagement (Attard & Curry, 2012), and in this project, it was an outstanding feature that students felt was beneficial. Rather than having to wait for their teachers to correct their work, the students were able to move forward with their learning. This, combined with the scaffolding mentioned earlier, enhanced the students' learning experiences.

Tied in with the instant feedback provided by Matific was its reward system. This feature was considered to be extremely engaging for almost all of the focus group students across the eight schools. There was only one student focus group, from School D, who felt the reward system was too childish for them, and wanted something more similar to typical non-educational video game rewards. The most significant benefit of the reward system was that it provided intrinsic motivation for students to continue working hard. The simple 'super awesome' statement promoted perseverance amongst almost all of the students, a characteristic that is important in mathematics learning, particularly in the area of problem solving. The students spoke about how they wanted to try harder when they got answers incorrect, in order to achieve a 'super awesome' status, with comments like this one being typical: "I kept on going back and back and I finally got five stars" (Year 6 student, School E).

The rewards system also promoted collaboration and peer mentoring amongst many of the students, rather than promoting competition amongst peers. This collaboration led to students accessing the Working Mathematically or Proficiency components, providing opportunities for students to communicate and reason. This tended to occur in classrooms where teachers had used several of Matific's affordances, as detailed earlier.

Matific is Fun

An outstanding feature of the Matific resources, according to the students, is that it is fun to use. The change from seeing mathematics as something to be tolerated or endured to

something that is fun indicates that there was high affective engagement. It should be noted that the word 'fun' did not simply equate to the game aspect of the resources. Rather, the data indicates that the students found it was fun because they felt they were learning. The focus of the lessons that included Matific remained on the mathematics rather than the game or the devices being used.

Overall, the use of Matific engaged students on operative, cognitive and affective levels. These three dimensions are inter-related. Students were cognitively engaged, that is, they were thinking hard about the mathematics, because the resources allowed them to interact with the activities and with their peers. They were affectively engaged because the activities were fun and they felt they were learning when the appropriately levelled episodes were set for classroom and homework tasks.

Challenges

Minor challenges were experienced by some of the teachers and students in this study. None of the schools in this study had access to a 1:1 device program. This was not intentional, and is the reality of many government and systemic Catholic primary schools. Likewise, internet connection issues are commonplace in many schools and this did interfere with the user experience of Matific in more than one school in this study.

Several of the teachers in this study found it was difficult to use Matific on an iPad, but this was because the actual iPad app had not been downloaded. In one school, it was typical for teachers to have to wait up to four weeks to have an app downloaded on their devices. Another significant issue was that of equity. Some teachers did not feel comfortable setting Matific episodes for homework because they were aware that not all students had access to the internet or to computers or tablets.

Achieving consistency amongst the schools in terms of the level of incorporation of Matific resources was a challenge that related to the diversity of teacher beliefs and abilities or confidence in terms of technology use. Although all of the teachers agreed to take part in the project activities, it was not possible or appropriate to expect that every single teacher would utilise all of Matific's affordances.

CONCLUSIONS AND RECOMMENDATIONS

This research evaluation sought to explore the effectiveness of Matific digital mathematics resources in assisting primary students to learn mathematics, and improve their engagement with the subject. The research took a multiple case study approach that included eight primary schools and 16 teachers and their students, ranging from Grade 2 to Grade 6 across a diverse range of contexts. Two teachers at each school planned a unit of work that incorporated the Matific resources. Qualitative and quantitative data was gathered from students prior to the use of the resources and on completion of their unit of work. Data was also gathered from their teachers.

Did Matific Assist Learning?

Evidence gathered indicates the Matific resources did help the students in this project learn mathematical concepts. This was due to the following reasons:

- the size and structure of the Matific episodes allowed the students to focus on very specific mathematical concepts and skills;
- the gradual increase in difficulty within each episode allowed students to achieve success;
- the Matific episodes provided assistance when answers were incorrect;
- in some cases, the Matific episode promoted mathematical discussion amongst students and between teachers and students that promoted deeper understanding; and
- the students were engaged in their learning.

Did Matific Improve Student Engagement?

It is clear from the data that the incorporation of Matific did improve overall engagement with mathematics for the majority of students involved in this project. It engaged those students through:

- providing immediate and constructive feedback,
- a reward system that improved intrinsic motivation and encouraged perseverance,
- promoting collaboration and peer tutoring,
- providing an alternative from pen and paper activities,
- providing the opportunity to practice classroom activities at home,
- allowing students to build confidence through the reward system, and
- making mathematics ‘fun’.

As with any project, challenges were experienced by teachers and their students. The data revealed potential areas for improvement, and the following recommendations are made:.

1: Development of 'just in time' professional learning resources

This project revealed a vast range of technological pedagogical content knowledge (TPACK) amongst the participating teachers. Their ability to incorporate the Matific resources varied, regardless of their depth of teaching experience. This related to different factors that included a lack of confidence in using the technology itself, a lack of knowledge in relation to integrating the technology into teaching practice, and limited knowledge in how the data generated by students' use of Matific could be used to inform practice. One-off, face-to-face professional development may not be the solution to this issue. Rather, it is suggested that Matific invest funds to develop a series of online professional learning videos that provide professional learning material to develop teachers' TPACK (not specifically related to using Matific resources). This material should be evidenced based. That is, it should have a foundation of educational theory and best practice. Short video snippets would provide 'just in time' learning for teachers and should include strong justification for suggested practices.

2. Provision of exemplars for using Matific when 1:1 devices are not available.

It is realistic to expect that few schools have access one device per student. For example, having group activities where a group of students works on Matific for part of the lesson before handing over devices to other students. Matific homework is another issue – teachers can provide alternate homework tasks to provide choice. Those without internet or computers at home could also be given the option to access school computers in library etc. out of school hours. These various scenarios can be detailed on the Matific website.

3. Designing an alternate structure for gathering student data

This recommendation directly links to Recommendation 2. When schools do not have access to 1:1 devices, an alternate system within Matific for recording group scores or for allocating students to groups, and tasks to groups would be beneficial. This would be of great benefit to the many teachers and students who do not have 1:1 access. Sharing devices can be beneficial to learning, as it promotes mathematical discussion and reasoning.

4. Embedding reflection prompts and linking the proficiencies/Working Mathematically into Matific episodes

It is strongly recommended that Matific include examples of reflection prompts that link to individual or groups of episodes. This would encourage teachers to consider Matific as more than an exercise in fluency, and would promote the Proficiencies/Working Mathematically components to enrich student learning and address a broader range of curriculum requirements.

5. Promote the use of Matific as a valuable source of assessment data

Many teachers still depend on pen and paper testing in mathematics yet if all aspects of Matific are used, valuable formative and/or summative assessment data is generated. A reminder of this within the Matific website, perhaps alongside reflection prompts would be beneficial in promoting Matific as something more valuable than fluency building.

6. Further integration of Proficiencies/Working Mathematically

Working Mathematically/Proficiencies integration needs to feature more prominently on the Matific website. Teachers need to be reminded that this should be embedded in all lessons, and understanding how to ensure Working Mathematically features in lessons that integrate Matific would make the resources more attractive to teachers and make mathematics lessons more valuable for students.

7. Further research

This study was limited in terms of the number of schools involved, the duration of the study, and the exclusion of a control or wait group. To gain a deeper understanding of the potential of Matific resources to improve mathematics learning and to gauge whether student engagement would eventually wane once the novelty of a new resource has worn off, it is recommended that a longitudinal study be conducted. This study should include a control or wait group, and should also incorporate data from caregivers to explore whether Matific could improve mathematics learning beyond the school classroom.

REFERENCES

Attard, C. (2015). Introducing iPads into Primary Mathematics Classrooms: Teachers' Experiences and Pedagogies. In M. Meletiou-Mavrotheris, K. Mavrou & E. Paparistodemou (Eds.), Integrating Touch Enabled and Mobile Devices into Contemporary Mathematics Education (pp. 197-217). Hershey, PA: IGI Global.

Attard, C. (2014). "I don't like it, I don't love it, but I do it and I don't mind": Introducing a framework for engagement with mathematics. *Curriculum Perspectives, 34*(3), 1-14.

Attard, C. (2013). "If I had to pick any subject, it wouldn't be maths": Foundations for engagement with mathematics during the middle years. *Mathematics Education Research Journal, 25*(4), 569-587.

Attard, C. (2011). Engagement with mathematics: The influence of teachers. *Southeast Asian Mathematics Education Journal, 1*(1), 31-39.

Attard, C, & Curry, C. (2012, July). Exploring the use of iPads to engage young students with mathematics. Paper presented at the Mathematics education: Expanding horizons, (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia) Singapore.

Australian Curriculum and Reporting Authority. (2012). Australian curriculum: Mathematics F-10. Retrieved October 30, 2012, from http://www.australiancurriculum.edu.au/Mathematics/Curriculum/F-10

Board of Studies New South Wales. (2012). Mathematics K-10 syllabus. Retrieved from http://syllabus.bos.nsw.edu.au/

Brigham, T. J. (2015). An introduction to gamification: Adding game elements for engagement. *Medical References Services Quarterly, 34*(4), 471-480.

Fair Go Team NSW Department of Education and Training. (2006). *School is for me: pathways to student engagement.* NSW Department of Education and Training: Sydney

Goehle, G., & Wagaman, J. (2016). The impact of gamification in web based homework. *Problems, Resources, and Issues in Mathematics Undergraduate Studies, 26*(6), 557-569.

Goos, M, Galbraith, P, Renshaw, P, & Geiger, V. (2000). Reshaping teacher and student roles in technology-enriched classrooms. *Mathematics Education Research Journal, 12*(3), 303-320.

Kingsley, T. L., & Grabner-Hagen, M. M. (2015). Gamification: Questing to integrate content knowledge, literacy, and 21st-century learning. *Journal of Adolescent and Adult Literacy, 59*(1), 51-61.

Levin, T., & Wadmany, R. (2008). Teachers' views on factors affecting effective integration of information technology in the classroom developmental scenery. Journal of Technology and Teacher Education, 16(2), 233-263.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technoogy and Teacher Education, 9*(1), 60-70.

Munns, G. (2007). A sense of wonder: pedagogies to engage students who live in poverty. *International journal of inclusive education, 11*(3), 301-315.

Munns, G., & Martin, A. J. (2005). *It's all about MeE: A motivation and engagement framework*. Paper presented at the Australian Association for Academic Research Focus Conference, Cairns. http://www.aare.edu.au/05pap/mun05400.pdf

Puentedura, R. (2006). SAMR. Retrieved from www.hippasus.com

Selwyn, N., Potter, J., & Cranmer, S. (2009). Primary pupils' use of information and communication technologies at school and home. *British Journal of Educational Technology, 40*(5), 919-932.

Shin, N., Sutherland, L. M., Norris, C. A., & Soloway, E. (2012). Effects of game technology on elementaty student learning in mathematics. *British Journal of Educational Technology, 43*(4), 540-560.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *American Educational Research Journal, 15*(2), 4-14.

van den Heuvel-Panhuizen, M. (2008). Learning from "didactikids": An impetus for revisiting the empty number line. *Mathematics Education Research Journal, 20*(3), 6-31.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.

Yelland, N., & Kilderry, A. (2010). Becoming numerate with information and communications techologies in the twenty-first century. International Journal of Early Years Education, 18(2), 91-106.

APPENDICES

Appendix 1: School A Unit of Work

<table>
<tr><td colspan="4">Mathematics – Whole number - place value, addition and subtraction</td></tr>
<tr><td colspan="2">Summary – to partition three-digit numbers into non-standard forms
To consolidate using an open number line to complete addition and subtraction questions</td><td colspan="2">Duration 1 lesson per week for 3 weeks (50 minute lessons)
A pre- test will be given to the students and this will be followed up with a post- test 3 weeks later</td></tr>
<tr><td colspan="2">Key Ideas -

Counts forwards and backwards by ones, from a three-digit number
Identify the numbers before and after a given three-digit number
Recognise, model, represent and order numbers to at least 1000
- Use the terms more than and less than to compare numbers
- Arrange number in ascending and descending order
Represent and solve addition and subtraction problems using a range of strategies, including counting on, partitioning and rearranging parts

Prior knowledge:
Students to have some understanding of number lines.</td><td colspan="2">Conceptual Understanding

Students will need to understand that
• There are more efficient ways to count collections than counting by ones
• Partitioning – children need to know how to partition numbers according to their place value</td></tr>
<tr><td colspan="2">Outcomes
• MA1 – 1WM
• MA1 – 4NA
• MA1 – 5NA</td><td colspan="2">Assessment overview
Rationale – To reinforce the concepts of place value following a grade assessment where results indicated many students are able to add and subtract two-digit numbers, however they lack a firm understanding of the process.</td></tr>
<tr><td colspan="3">Content

• Use place value to partition three-digit numbers eg. 326 as 3 groups of one hundred, 2 groups of ten and 6 ones
• That three –digit number s can be partitioned into non-standard forms eg 326 can be 32 groups of ten and 6 ones
• Use number lines and number charts beyond 100 and assist with counting and ordering
• Apply an understanding of place value and the role of zero to read, write and order three-digit numbers</td><td>Resources

• Matific
• Toe the line
• Piled up
• Ship it out
• Bubble add up</td></tr>
<tr><td colspan="4">Lesson 1: Explanation of partitioning and using open number line</td></tr>
<tr><td>Whole class

Resources: IWB</td><td colspan="2">On IWB display the number 24 – have students give information about the number (Questioning: What is it made up of? How can it be made? Is it even/odd? How can it be made? Etc.)

Show students a partitioned 24. Explaining how it is made up of 2 tens and 4 units.</td><td>10 mins</td></tr>
<tr><td>Whole class

Resources: IWB</td><td colspan="2">Display 24 within a number sentence
24+20=
Ask students to partition both numbers and draw on board.
Show students how to solve sentence on an open number line.
Putting 20 on the number line and explicitly jumping by tens (making two tens jumps) and units jumps (four smaller jumps).</td><td>20 mins</td></tr>
</table>

	Questioning: Why were only 2 tens jumps made? Why were only 4 units? Have students count aloud each jump: **i.e.: 20,** (tens jump), 30, (tens jump), 40, (unit jump), 41, (unit jump), 42, (unit jump), 43, (unit jump), **44.** Explicitly explain that the number that was finished is the answer. Repeat with different number sentences.	
Individual **Resources:** ipads/computers	**Matific Toe the line** Students directed to the three number line activities. Toe the line (label up to 100) https://www.matific.com/au/en-au/activity/UnderstandingNumberLinesTagsTo100 Toe the line (5 skips) https://www.matific.com/au/en-au/activity/UnderstandingNumberLinesSkip5 Toe the line (Adding on the number line) https://www.matific.com/au/en-au/activity/UnderstandingNumberLinesAddSub	20 mins
Lesson 2: Review and activity rotations		
Whole class	Revise previous lesson as a whole class (partitioning numbers and solving problems on open number line).	10 mins
Group/ individual **Resources:** Activity 1 – Ipads/computers Activity 2 – Ipads/ computers Activity 3 – Dice, whiteboards/ maths books. Activity 4 – Dice, maths books	Students are divided into small groups (4-6) and directed towards activities and rotate (10 mins each rotation) **Activity 1:** Matific – Piled up https://www.matific.com/au/en-au/activity/PileComparison2PilesUpTo100 Ship it out https://www.matific.com/au/en-au/activity/TruckLoadingHundreds **Activity 2:** Matific – Toe the line (Adding on the number line) https://www.matific.com/au/en-au/activity/UnderstandingNumberLinesAddSub **Activity 3:** Rolling dice game – Students roll 2 dice partition both numbers and add on an open number line (record on white boards/ or in maths books). Differentiate this activity by getting more capable children to keep going onto 100s. Less capable children to work with the teacher to consolidate the concept.	40 mins (10 mins each activity)

	Activity 4: Numeral expander – students roll three dice, first dice is hundreds, second dice is tens and third dice is units. Student make numbers then work out how many hundreds, tens and units. For example the number 256 has 5 tens but also has 25 tens. Students write answers in books.	
Lesson 3:		
Individual Resources: Ipads/computers	Students are given time to work though both worksheets and games: Teacher to differentiate activities for each student (giving lower students revision activities and early level games and giving higher students increasingly challenging activities). Matific worksheets Adding tens: https://www.matific.com/au/en-au/activity/GenericWorksheetAdditionOfTensUpTo100 https://www.matific.com/au/en-au/activity/GenericWorksheetAdditionOfTensWithUnknownsUpTo100 Matific games Bubble addition: https://www.matific.com/au/en-au/activity/BubbleAdditionTwoDigits Toe the line (Adding on the number line) https://www.matific.com/au/en-au/activity/UnderstandingNumberLinesAddSub Piled up: https://www.matific.com/au/en-au/activity/PileComparison4PilesUpTo100 https://www.matific.com/au/en-au/activity/PileComparison2PilesUpTo1000	50 mins
Observations and evaluation Pre test Observing students during lessons and group work Post- test after three weeks	**Language** – more than, less than, number before, number after, zero, Hundreds, tens, ones, place value 'If I have more than ten ones, I can replace them with one ten……'	

Appendix 2: School A Pre- and Post-Tests

Pre Test

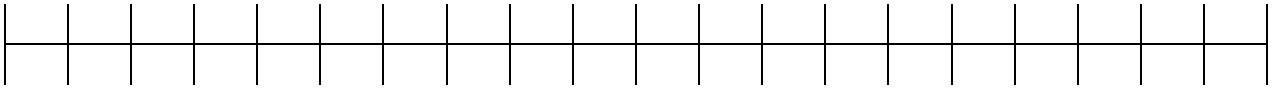
Name: _____

Date:_____

1. Mark in the correct numbers on the number line:

- Mark 8 after 24 with a ■
- Mark 5 before 24 with a ★

/2



24

2. Mark in the correct numbers on the number line:

- Mark 5 after 36 with a ×
- Mark 8 before 36 with a O

/2

36

3. Solve:

67 = 50 + ☐ 70 = 83 – ☐

/2

4. What is 100 less than 108? /1

_____

/1

5. What is 100 more than 206?

_____

6. Solve:

50 + 32 = /3

50

Using words and sentences describe how you solved the problem:

7. Solve:
74 - 42 =

/3

74

Using words and sentences describe how you solved the problem:

Total /14

Post test

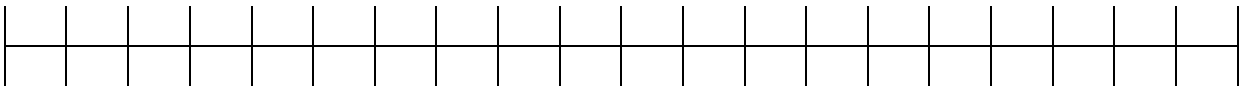
Name: _____

Date:_____

8. Mark in the correct numbers on the number line:

- Mark 9 after 36 with a ■
- Mark 7 before 36 with a ★

/2



36

9. Mark in the correct numbers on the number line:

- Mark 5 after 42 with a ×
- Mark 8 before 42 with a O

/2

42

10. Solve:

73 = 40 + ☐ 60 = 83 – ☐

/2

11. What is 100 less than 103?

/1

_____

/1

12. What is 100 more than 309?

_____

13. Solve:

60 + 46 =

/3

60

Using words and sentences describe how you solved the problem:

14. Solve:

62 - 39 =

/3

62

Using words and sentences describe how you solved the problem:

Total /14

Appendix 3: School B Unit of Work

<table>
<tr><td colspan="3">Mathematics- Time</td></tr>
<tr><td>Summary</td><td colspan="2"></td></tr>
<tr><td>Key Ideas</td><td colspan="2">Conceptual Understanding</td></tr>
<tr><td>– Tell time to the minute and investigate the relationship between units of time (ACMMG062)
– Convert between units of time (ACMMG085)
– Model and represent unit fractions, including and their multiples, to a complete whole (ACMNA058)</td><td colspan="2">Student will understand that:
– Time is a unit of measure
– Fractions, including halves and quarters, are used to tell time</td></tr>
<tr><td colspan="3">Outcomes: MA2-1WM, MA2-13MG, MA2-7NA</td></tr>
<tr><td colspan="3">Rationale: Students develop increasingly sophisticated and refined understanding about time, enabling them to access improved fluency, ability to communicate and justify answers and effectively solve problems.</td></tr>
<tr><td>Content</td><td>Teaching, learning and assessment</td><td>Resources</td></tr>
<tr><td>Time1:
– Recognise the coordinated movements of the hands on an analog clock (movements of minute, hour and second hand)
Time 2:
– Explain the relationship between the size of a unit and the number of units needed,
– Record digital time using the correct notation, including am and pm, eg 9:15 am describe times given using am and pm notation in relation to 'midday' (or 'noon') and 'midnight', eg '3:15 pm is three and a quarter hours after midday'
– Relate analog notation to digital notation for time, eg ten to nine in the morning is the same time as 8:50 am
Fractions 1:
– Model fractions with denominators of 2, 4 and 8 of whole objects, shapes and collections using concrete materials and diagrams
– Recognise that as the number of parts that a whole is divided into becomes larger, the size of each part becomes smaller (reasoning)
– Recognise that fractions are used to describe one or more parts of a whole where the parts are equal
– Interpret the denominator as the number of equal parts a whole has been divided into
– Interpret the numerator as the number of equal fractional parts, eg means 3 equal parts of 8</td><td>1. Pre-test (use this to form differentiated groups)
2. Time scavenger hunt
3. Discussion about time, eg seconds, minutes. Model halves and quarters using a clock (Matific; Know the half of it)
4. Draw own clock faces including all features that they know. Share and compare clock faces in small groups. Discuss the importance of the marks around the clock- representing 60 seconds/minutes.
5. Maths rotations
-Modelled/guided group
-Ipad- (Matific; Stop the clock)
-Set and draw times using blank clocks
-Match game (flip and match analogue to digital)
-Extension: problem solving activities eg How many days have you attended school this year?
4. Maths rotations continued
5. How many ways?

6. Post assessment</td><td>-Stop the clock (hours/half hours)
-Stop the clock (before and after)
-Stop the clock (digital and analogue time)
-Stop the clock (minute)

-The monster share (halves)
-Know the half of it (halves)
-Know the half of it (halves and quarters)
-Whiteboards
-Cardboard clock faces</td></tr>
</table>

Observations and evaluation Pre test Assessment grids- notes Post test	Language: **Time 1**: time, clock, analogue, digital, hour hand, minute hand, second hand , revolution , numeral, hour, minute, second, o'clock, (minutes) past , (minutes) to . **Time 2:** (all of Time 1) midday, noon, midnight, am (notation), pm (notation). **Fractions 1:** whole, part, equal parts, half, quarter, eighth, fraction , denominator , numerator.	

Appendix 4: School B Pre- and Post-tests

Pre-test

Name:_____ Date:_____

1. How many seconds are in:
1 minute:

2. How many minutes in:
2 hours:

3. How many hours in:
2 and a half days:

4. How many hours past midnight is:
3:45 am:
How many hours past midday/noon is:
2:30 am:

5. Jenny said the best unit to measure a day is minutes. Do you agree and why?

_____

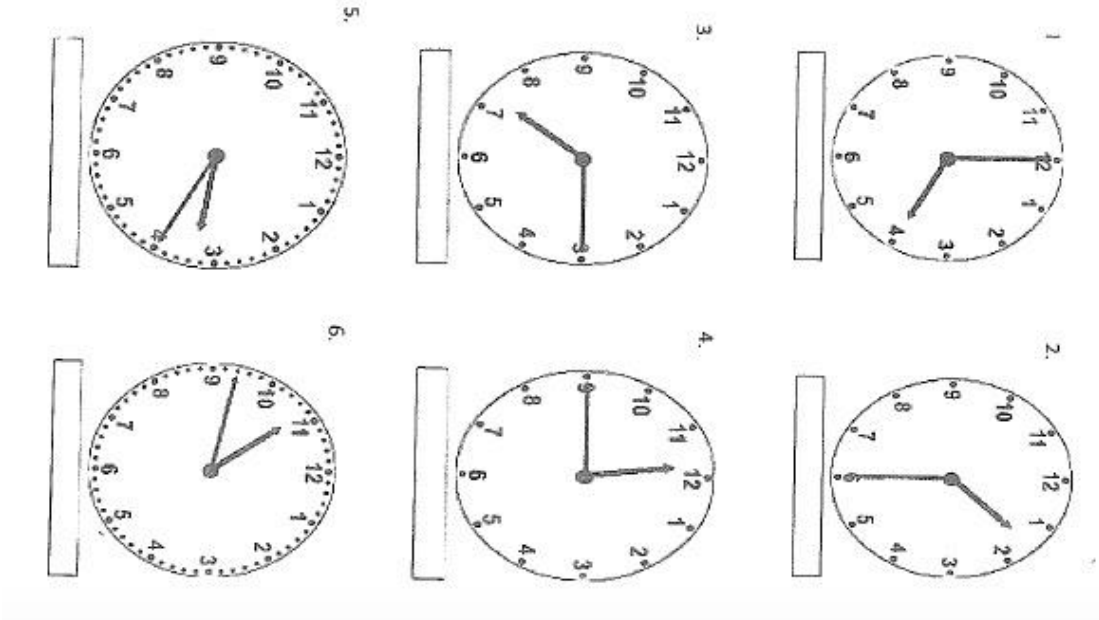
_____

_____

_____

6. Write these times as digital time using am or pm:

Ten to nine in the morning	:
Quarter past three in the afternoon	:
Quarter to 7 in the morning	:



How many minutes have past?

How many minutes have past?_____

How many minutes have past?_____

How many minutes have past?_____

How many seconds does the second hand take to complete one revolution?_____

Post-test

Name:_____ Date:_____

1. How long does it take for the following hand to complete one revolution:
Second hand_____
Hour hand _____
Minute hand _____

4. How many hours past midnight is:
5:00 am:
How many hours past midday/noon is:
7:30 am:

5. Sam thinks the best way to measure the time he spends at school is to count using seconds. Do you agree and why?
_____
_____
_____
_____

6. Write these times as digital time using am or pm:	
Ten to seven in the morning	:
Quarter past five in the afternoon	:
Quarter to 10 in the morning	:

Name:_____ Date:_____

Compare these clocks!

Look at the two clocks below. How many minutes have past from the starting time to the finish time?

Starting time:_____

Finish time:_____

How many minutes have past?_____

How many minutes have past?_____

How many minutes have past?_____

Appendix 5: School C, Year 5 Unit of Work

<table>
<tr><td colspan="2">MATHEMATICS MEASUREMENT & GEOMETRY – MASS
GRADE : YEAR 5 TERM : 2 WEEK : 7</td></tr>
<tr><td>OUTCOMES MA3-12MG
Selects and uses the appropriate unit and devices to find the mass of objects and convert between units of mass.</td><td>UNIT DESCRIPTION
Students select and use the appropriate unit to estimate, measure and calculate mass.</td></tr>
<tr><td>KEY IDEAS
Select and use the appropriate unit and devices to measure mass of a variety of objects.
Convert between grams and kilograms and tonnes.
Record mass using decimal notation to three places</td><td>LANGUAGE
mass, grams, kilograms, tonnes, estimate, measure calculate, calibration, decimal point, decimal notation, relationship, converting, measuring device, balance, spring balance, scales, scale, adjustment, nearest, approximate</td></tr>
<tr><td>LEARNING SEQUENCE</td><td>WORKING MATHEMATICALLY</td></tr>
<tr><td>Automaticity Drills
• rounding to nearest kilogram, tonne,
• number clouds – rounding, closest to, largest, smallest
• multiplication tables 7s
• quick recall facts eg. 2.5kg = 2500 grams

Explicit Teaching
• identifies objects that have a mass more than, less than or about the same as one kilogram
• estimates, measures and records the mass of objects to
the nearest kilogram or gram using an equal arm balance
• uses the abbreviation for kilograms (kg) and grams (g)
• explains the need for a unit smaller than a kilogram to
measure mass
• measures mass using a given measuring device eg a kitchen scale, balance scale
• converts between kilograms and grams
https://www.matific.com/au/en-au/activity/ScalesMultiplicationAndDivisionPuzzles
• estimates and checks the number of similar objects which have a total mass of one kilogram
• orders commercial products by interpreting labelling
eg a 1.25 kg box of cereal has a greater mass than a
625 g tin of fruit</td><td>Students learn to
• describe how a mass was estimated and measured (Communicating)
• explain the relationship between the size of a unit and the number of units needed to measure mass (Communicating, Reflecting)
• question and explain why two students may obtain different measures for the same mass
(Questioning, Communicating, Reasoning)
• interpret scales on different measuring devices to calculate mass (Applying Strategies, Communicating)
• solve problems involving different units of mass (Applying)
• solve problems involving mass and the price of gold. (Applying Strategies)

RICH TASK
• Find a collection of objects with a total mass of 2.5 kilograms. List these and total the combined mass.
• A jar of marbles weighs 1kilogram. How much might each marble weigh? How much might the jar weigh

https://www.matific.com/au/en-au/activity/ScalesMultiplicationAndDivisionMultiplication

https://www.matific.com/au/en-au/activity/DecimalAdditionWithScalesWeigh

https://www.matific.com/au/en-au/activity/WeighingMattersDecimalsRound</td></tr>
</table>

• Groceries - net mass and gross mass https://www.matific.com/au/en-au/activity/WeighingRiddlesBasicAddAndSub • names objects and materials whose mass is measured in tonnes eg sand, soil, vehicles • uses the abbreviation for tonne (t) Connor, Emma, Ben stop here • converts between kilograms and tonnes • uses decimal notation to three decimal places when recording mass https://www.matific.com/au/en-au/activity/DecimalAdditionWithScalesWeigh • convert mass of 5 cars from kilograms into tonnes using decimal notation • place cars in order of mass from lightest to heaviest • calculate how many smaller masses (200 kg, 500 kg, 50 kg, 250 kg and 10 kg) equal 1 tonnes.	**PLANNED ASSESSMENT** • A checklist of student achievement of daily focus • Maths Plus 5 – p17, 81, 105 • Maths Plus 4 – p47, 67, 101 (if needed) • Rich task – paired activity. • https://www.matific.com/au (pre-test / post-test)
RESOURCES • Maths Plus Interactive CD-ROM • Open- ended Maths Activities (Blue) • Mathematics K-6 Syllabus, Sample Units. • https://www.matific.com/au	**DIFFERENTIATION** • Connor, Emma, Taylor, Ben task monitored and different exit points • See Maths KLA organisation for details

Appendix 6: School C, Year 5 Pre- and Post-test

Name .....

MEASUREMENT – MASS YEAR 5 (PRE TEST / POST TEST)

Kilograms

Mass is measured in kilograms. The symbol for kilograms is kg. There are 1000 grams in a kilogram.

Use the information above to calculate how many apples you would need to balance:

11 the avocado.

12 the sugar.

13 the rockmelon.

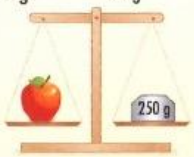
14 the flour.

15 the washing powder.

16 the potatoes.

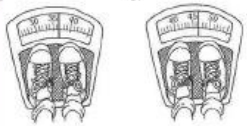
17 How many oranges would be needed to balance a rockmelon?

18 How many oranges would be needed to balance the flour?



Write the **mass** of each person

a. b.



Mass = _____ Mass = _____

1 Calculate the gross mass of these items.

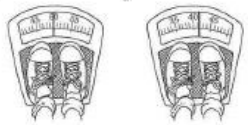
Item	Net Mass	Packaging	Gross Mass
a Coffee	490 g	10 g	_____
b Spaghetti	805 g	20 g	_____
c Wedges	750 g	5 g	_____
d Peanuts	375 g	2 g	_____
e Choc drink	450 g	10 g	_____

Name .....

MEASUREMENT – MASS YEAR 5 (PRE TEST / POST TEST)

in **kilograms.**

c. d.



Mass = _____ Mass = _____

28 Convert these measurements from tonnes to kilograms without the use of a calculator. Then use a calculator to check your conversions.

Kilograms	1459	2759	3500	3456	23 456	45 129
Tonnes	1.459 t					

29 Choose the appropriate mass unit to measure the mass of a:

Write g, kg or t.

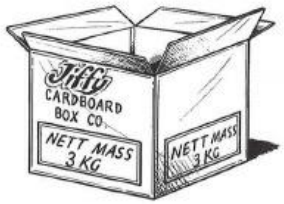
a	matchbox	____	e	elephant	____	i	gluestick	____
b	dog	____	f	ruler	____	j	desk	____
c	pencil	____	g	ship	____	k	whale	____
d	person	____	h	pony	____	l	building	____

30 Write each kilogram measurement in grams.

a	2 kg = _____ g	c	3.250 kg = _____ g	e	4.566 kg = _____ g
b	2.5 kg = _____ g	d	4.750 kg = _____ g	f	12.356 kg = _____ g

31 A cardboard box can hold a net mass of 3 kg. How many of each item could be packed into a box of this type?

a ☐ b ☐ c ☐ d ☐



32 If you put 3 books and 3 calculators in the box, would you exceed its net mass? _____

Name .....

MEASUREMENT – MASS **YEAR 5** **(PRE TEST / POST TEST)**

1 The weighbridge at Modern Tran Tip records the amount of waste tipped by the local council trucks over the week. Help calculate each truck's total.
Estimate your answer first then calculate the exact answer.

a

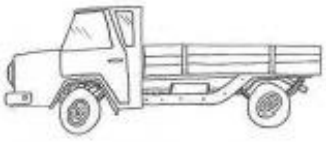
MODERN TRAN TIP

Truck No: 207	Total Mass (t)	Load (t)
Tare: 4·2 t	6·3	
Week 7/5 to 14/5	9·2	
	7·8	
Total Load Tipped	8·9	
_____ t		

c

MODERN TRAN TIP

Truck No: 211	Total Mass (t)	Load (t)
Tare: 8·3 t	12·8	
Week 7/5 to 14/5	16·4	
	9·2	
To	10·7	
Total Load Tipped	9·7	
_____ t		



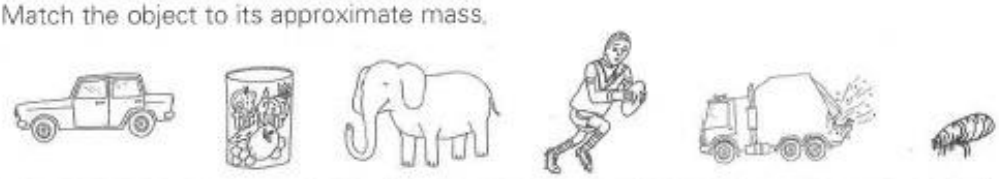
2 Are these masses correctly ordered from least to most?

a 0·12 t, 130 kg, 156 kg _____

b 5 000 g, 6·7 kg, 2 t _____

c 280 g, 0·26 kg, 2·6 t _____

3 Match the object to its approximate mass.



3·8 t	400 g	1 t	5 t	100 kg	1 g

4 Circle the one which is better value for money?

a 

2 kg for $3.50 or 1·5 kg for $2.70

b 

5 kg for $6.99 or 1 kg for $2

c 

3·5 kg for $7 or 7 kg for $12

Appendix 7: School C, Year 6 Unit of Work

KLA: Mathematics

SCHOOL: **STAGE:** Three **CLASS:** Six **TERM:** 2 **2016**

TEACHER:

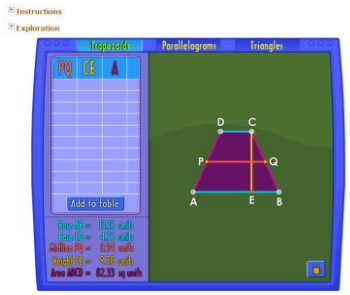
<table>
<tr><td>STRAND Measurement and Geometry</td><td rowspan="2">FOCUS OUTCOMES
MA3-1WM
MA3-2WM
MA3-9MG
MA3-10MG</td><td rowspan="2">TERM 1 2 3 4

WEEK 1 2 3 4 5 6 7 8 9 10 11</td></tr>
<tr><td>SUB STRAND
Length 2
Area 2</td></tr>
<tr><td colspan="3">UNIT DESCRIPTION: Solve problems involving the comparison of lengths using appropriate units
investigate and compare perimeters of rectangles with the same area
determine the number of different rectangles that can be formed using whole-number dimensions for a given area (Problem Solving, Reasoning)
solve a variety of problems involving length and perimeter, including problems involving different units of length,
convert between metres and kilometres
convert between millimetres, centimetres and metres to compare lengths and distances
explain and use the relationship between the size of a unit and the number of units needed to assist in determining whether multiplication or division is required when converting between units
investigate and compare the areas of rectangles that have the same perimeter, eg compare the areas of all possible rectangles with whole-number dimensions and a perimeter of 20 centimetres
determine the number of different rectangles that can be formed using whole-number dimensions for a given perimeter (Problem Solving, Reasoning)
solve a variety of problems involving the areas of rectangles (including squares) and triangles</td></tr>
<tr><td>MODIFIED ACTIVITY</td><td>MAIN TEACHING and LEARNING ACTIVITY</td><td>EXTENDED ACTIVITY</td></tr>
<tr><td>Chn work in small groups with CT/LSA assistance

Revise and review understanding of perimeter and area of rectangles using:</td><td>Daily Count Me In Automaticity activities – counting back/forwards by 5s,10s,100s,1000s… from a given number
Number identification-rounding, largest, smallest, closest to

ASSESSMENT TASK
Pre-test outcome- based tasks</td><td>Daily Count Me In activities centred around place value to 4 digits</td></tr>
</table>

http://www.mathplayground.com/area_perimeter.html With LSA support, highlight **perimeter** of a drawn shape and fill the **area**, label shape. Measure to work out the perimeter and then area for the shape. Record each measurement and explain the formula for each. Calculate perimeter and area https://www.matific.com/au/enau/activity/ParkPlanningOneDigitMetric https://www.matific.com/au/enau/activity/ParkPlanningOneDigitMetric Calculate the area of rectangles and squares then use halving to solve the area of triangles using square units. Shapes on the Grid-right triangle https://www.matific.com/au/en-au/activity/ShapesOnGridRightTriangles Calculate the area of a bigger shape using square units of set area Measuring Area including 4 episodes: • Cover by Rectangles • Split and Conquer • Air and Square • Shapes on the Grid-area estimation https://www.matific.com/au/en-au/curriculum/6G/Measurement%20and%20geometry/Area?episode=MeasuringAreaLevelII **ASSESSMENT TASK** Post-test outcome-based tasks with pre-test.	Highlight **perimeter** of a drawn shape and fill the **area**, label shape. Measure to work out the perimeter and then area for the shape. Record each measurement and explain the formula for each. Calculate perimeter and use to solve area –MATIFIC ACTIVITY 3 and 4 Fenced in – level III https://www.matific.com/au/en-au/activity/ParkPlanningOneDigitAddAndSubtractMetric Fenced in level III https://www.matific.com/au/en-au/activity/ParkPlanningTwoDigitMetric Solve various area and perimeter problems set out on a spreadsheet format E:\2016\ Year 6 2016\MATHS\TERM 2\ Copy of spreadsheets_area.xls **ASSESSMENT TASK** Post-test outcome-based tasks with pre-test	Using three different areas, calculate and record three different rectangles for each that could be formed. Calculate area and perimeter with conversion between millimetres, centimetres and metres https://www.matific.com/au/enau/activity/ParkPlanningMeterCm Solve various area and perimeter problems set out on a spreadsheet format E:\2016\Year 6 2016\MATHS\TERM 2\Copy of spreadsheets_area.xls **ASSESSMENT TASK** Zoo Perimeter and Area Project –design a zoo to fit particular requirements see NOTEBOOK **ASSESSMENT TASK** Complete area worksheet with conversions required for measurements Students can use this tool to determine how the length of the base and the height of a shape can be used to determine its area. They can find the similarities and differences between the area formulas for triangles, also

Complete more examples with CT or LSA support		trapezoids and  parallelograms. http://illuminations.nctm.org/ActivityDetail.aspx?ID=108
RESOURCES Maths Plus 6 MATIFIC Tablets Grid and dot paper		
REFLECTION and EVALUATION		

Appendix 8: School C, Year 6 Pre- and Post-test

MA3 1OMG selects and uses the appropriate unit to calculate areas, including areas of squares, rectangles and triangles

A B C D E

A=LxB

12 cm

7 cm

perimeter = 12+12+7+7 = 38cm

area = 12x 7= 84cm²

13/17

8 cm

4 cm

perimeter = 8+8+4+4 = 24cm

area = 8x4 = 32cm²

16/17

Can you find the areas of these shapes?

You may do your working out on paper

2cm 2x3=6 3cm Area= 6cm²

1cm 1x6=6 6cm Area = 6cm²

7cm 3.5cm 7x3=21÷2=10.5 3cm Area= 10.5cm²

Find the area of each rectangle and shaded triangle.

a. 4cm 4x4= 4x2=

area of the square = 16cm²

area of the triangle = 8cm²

e. 11mm 8mm 11x4= 11x2=

area of the rectangle = 44mm²

area of the triangle = 22mm²

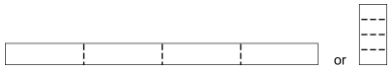
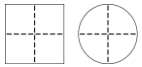
c. 6km 8km 6x8= 6x4=

area of the rectangle = 48Km²

area of the triangle = 24 Km²

Appendix 9: School D Unit of Work

Year 4 Mathematics Program **Strand: Number and Algebra** **Sub-strand: Fractions and Decimals**

WORKING MATHEMATICALLY OUTCOMES	CONTENT OUTCOMES	Background Information
MA2-1WM - uses appropriate terminology to describe, and symbols to represent, mathematical ideas MA2-3WM - checks the accuracy of a statement and explains the reasoning used MA2-7NA - represents, models and compares commonly used fractions and decimals	**Model and represent unit fractions, including 1/2, 1/4, 1/3 and 1/5 and their multiples, to a complete whole (ACMNA058)** **Count by quarters, halves and thirds, including with mixed numerals; locate and represent these fractions on a number line (ACMNA078)** **Investigate equivalent fractions used in contexts (ACMNA077)** **Recognise that the place value system can be extended to tenths and hundredths, and make connections between fractions and decimal notation (ACMNA079)**	**Percentages are not introduced until Stage 3. Improper fractions are not introduced until Stage 3.** **Greater emphasis is placed on identifying and describing fractions.** **Unit 1** In Stage 2 Fractions and Decimals 1, fractions with denominators of 2, 3, 4, 5 and 8 are studied. Denominators of 6, 10 and 100 are introduced in Stage 2 Fractions and Decimals 2. Fractions are used in different ways: to describe equal parts of a whole; to describe equal parts of a collection of objects; to denote numbers (eg 12 is midway between 0 and 1 on the number line); and as operators related to division (eg dividing a number in half). A unit fraction is any proper fraction in which the numerator is 1, eg 12, 13, 14, 15, … Three Models of Fractions *Continuous model, linear* – uses one-directional cuts or folds that compare fractional parts based on length. Cuts or folds may be either vertical or horizontal. This model was introduced in Stage 1.  *Continuous model, area* – uses multi-directional cuts or folds to compare fractional parts to the whole. This model should be introduced once students have an understanding of the concept of area in Stage 2.  *Discrete model* – uses separate items in collections to represent parts of the whole group. This model was introduced in Stage 1.  **Unit 2** In Stage 2 Fractions and Decimals 2, fractions with denominators of 2, 3, 4, 5, 6, 8, 10 and 100 are studied. Denominators of 2, 3, 4, 5 and 8 were introduced in Stage 2 Fractions and Decimals 1. Fractions are used in different ways: to describe equal parts of a whole; to describe

		equal parts of a collection of objects; to denote numbers (eg 12 is midway between 0 and 1 on the number line); and as operators related to division (eg dividing a number in half). Money is an application of decimals to two decimal places.
LEARNING GOALS	**MATHEMATICAL LANGUAGE**	**ASSESSMENT – FOR, OF, AS**
We are learning to: * use appropriate language to describe and symbols to represent *to check the accuracy of our work and explain our reasoning *to investigate equivalent fractions *to see that place value extends to tenths and hundreds and to make connections between fractions and decimal notation	whole, part, equal parts, half, quarter, eighth, **third**, **fifth**, **one-third**, **one-fifth**, **fraction**, **denominator**, **numerator**, **mixed numeral**, **whole number**, **fractional part**, **number line**. When expressing fractions in English, the numerator is said first, followed by the denominator. However, in many Asian languages (eg Chinese, Japanese), the opposite is the case: the denominator is said before the numerator.	***written assessment** ***target assessment** ***reflection journal-**

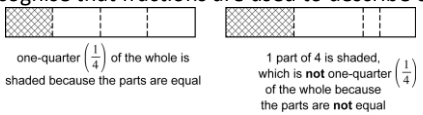
Model and represent unit fractions, including 1/2, 1/4, 1/3 and 1/5 and their multiples, to a complete whole (ACMNA058)

model fractions with denominators of 2, 3, 4, 5 and 8 of whole objects, shapes and collections using concrete materials and diagrams, eg

$\frac{3}{5}$

recognise that as the number of parts that a whole is divided into becomes larger, the size of each part becomes smaller (Reasoning)

recognise that fractions are used to describe one or more parts of a whole where the parts are equal,



eg

(Communicating, Reasoning)

name fractions up to one whole, eg 1/5, 2/5, 3/5, 4/5, 5/5

interpret the denominator as the number of equal parts a whole has been divided into

interpret the numerator as the number of equal fractional parts, eg 38 means 3 equal parts of 8

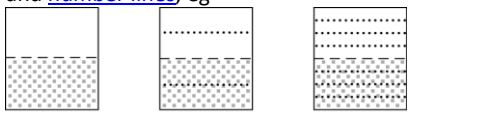
use the terms 'fraction', 'denominator' and 'numerator' appropriately when referring to fractions

Count by quarters, halves and thirds, including with mixed numerals; locate and represent these

Investigate equivalent fractions used in contexts (ACMNA077)

model, compare and represent fractions with denominators of 2, 4 and 8; 3 and 6; and 5, 10 and 100

model, compare and represent the equivalence of fractions with related denominators by redividing the whole, using concrete materials, diagrams and number lines, eg



$\frac{1}{2}$ $\frac{2}{4}$ $\frac{4}{8}$

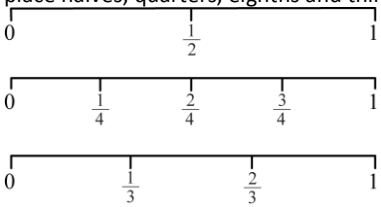
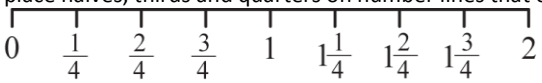
record equivalent fractions using diagrams and numerals, eg 3/5=6/10

Recognise that the place value system can be extended to tenths and hundredths, and make connections between fractions and decimal notation (ACMNA079)

recognise and apply decimal notation to express whole numbers, tenths and hundredths as decimals, eg 0.1 is the same as 1/10

investigate equivalences using various methods, eg use a number line or a calculator to show that 1/2 is the same as 0.5 and 5/10 (Communicating, Reasoning)

identify and interpret the everyday use of fractions and decimals, such as those in

fractions on a number line (ACMNA078) identify and describe 'mixed numerals' as having a whole-number part and a fractional part rename 22, 33, 44, 55 and 88 as 1 count by halves, thirds and quarters, eg 0, 13, 23, 1, 113, 123, 2, 213, … place halves, quarters, eighths and thirds on number lines between 0 and 1, eg  place halves, thirds and quarters on number lines that extend beyond 1, eg  compare unit fractions using diagrams and number lines and by referring to the denominator, eg 18 is less than 12 recognise and explain the relationship between the value of a unit fraction and its denominator (Communicating, Reasoning)	advertisements (Communicating, Problem Solving) state the place value of digits in decimal numbers of up to two decimal places use place value to partition decimals of up to two decimal places, eg 5.37=5+3/10+7/100 partition decimals of up to two decimal places in non-standard forms, eg 5.37=5+37100 apply knowledge of hundredths to represent amounts of money in decimal form, eg five dollars and 35 cents is 535/100, which is the same as $5.35 (Communicating) model, compare and represent decimals of up to two decimal places apply knowledge of decimals to record measurements, eg 123 cm = 1.23 m (Communicating) interpret zero digit(s) at the end of a decimal, eg 0.70 has the same value as 0.7, 3.00 and 3.0 have the same value as 3 (Communicating) recognise that amounts of money are written with two decimal places, eg $4.30 is not written as $4.3 (Communicating) use one of the symbols for dollars ($) and cents (c) correctly when expressing amounts of money, ie $5.67 and 567c are correct, but $5.67c is not (Communicating) use a calculator to create patterns involving decimal numbers, eg 1 ÷ 10, 2 ÷ 10, 3 ÷ 10 (Communicating) place decimals of up to two decimal places on a number line, eg place 0.5, 0.25 and 0.75 on a number line round a number with one or two decimal places to the nearest whole number

SESSION: 1 represent, model and compare numbers as fractions *(visualising fractions)*

WARM UP/IGNITION:	WORD PROBLEM:	
Skip count by 3s, 4s and 6s. Revise fractions: http://www.bgfl.org/custom/resources_ftp/client_ftp/ks2/maths/fractions/ http://www.topmarks.co.uk/Flash.aspx?f=WhatFractionv3	Mum gave me a sandwich for lunch. She said I could eat 2/4 at recess and 2/4 at lunch time. Draw how much I can eat at each break.	
EXPLICIT TEACHING/MODELLING:	**DIFFERENTIATION:**	**RESOURCES:**
Learning goal: We are learning to represent, model and compare numbers as fractions and decimals. *Deconstruct learning goal and display vocab: whole, part, equal parts, half, quarter, eighth, third, **sixth**, fifth, **tenth**, **hundredth**, **one-sixth**, **one-tenth**, **one-hundredth**, fraction, numerator, denominator, whole number, number line, **is equal to**, **equivalent fractions**, **decimal**, **decimal point**, **digit**, **place value**, **round to**, **decimal places**, **dollars**, **cents** **MATIFIC revision – BIRDS ON THE WIRE** **https://www.matific.com/au/en-au/activity/BirdsOnWireFractionsIdentify** **teacher activity followed by student activity MATIFIC revision – Wholes and Parts** **https://www.matific.com/au/en-au/activity/FractionsModelsDisplayFractions** *Introduce how we can represent whole numbers and parts of numbers. Example, we can represent with pictures, numbers, and words. *Explain to students that we will be representing whole numbers and parts using pictures, words and numbers. On whiteboard, draw three columns with the labels- pictures, numbers and words.	Differentiate for ability levels- students who can identify halves and quarters easily can work on thirds, sixths and twelfths, while students who still need to work on halves and quarters can just do those with	*chocolate bar blown up on A3 paper * blu tack/magnets to attach to white board. * photocopies of 3 individual chocolate bars for each student

<table>
<tr><td colspan="2">* Display an image of a whole chocolate bar and place in the ‘pictures’ column. Ask students how they can represent it as numbers. i.e. 1 (whole), 1/1, 100%, 1 x 1, 1 whole, etc.
* Tell students that we also need to represent the chocolate bar in words. Model a word problem using the chocolate bar. e.g. Ali has 1 whole chocolate bar and is going to share it amongst 4 friends. How many pieces will each friend receive?</td><td rowspan="3">or without teacher assistance.</td><td rowspan="3">* A3 size paper
* plastic sandwich bag/or envelope for each student.
scissors
glue</td></tr>
<tr><td colspan="2">GUIDED TEACHING:</td></tr>
<tr><td colspan="2">* Students are given an A3 paper and their own chocolate bars sheets.
* Students fold A3 paper into thirds. In each column they will write, ‘pictures’, ‘numbers’, ‘words’.
*Students are instructed to share the chocolate bars into halves, quarters, thirds, sixths and twelfths by cutting them into appropriate strips. E.g. Cut chocolate bar into sixths and record on paper.--> Do not glue on paper as the strips will be used again. Keep in an envelope or plastic sandwich bag for each student.
* Students share their findings as a class
<table>
<tr><th>Picture</th><th>Numbers</th><th>Words</th></tr>
<tr><td> 
</td><td>1/6 + 1/6 +1/6 + 1/6 +1/6 + 1/6 = 6/6
1 whole
6/6 = 12/12</td><td>Sifat had a block of chocolate which contained 12 individual pieces and wanted to share it between 6 friends. How many pieces of the chocolate bar would each friend get?</td></tr>
</table></td></tr>
<tr><td colspan="2">REFLECTION/WHERE TO NEXT:</td><td></td><td></td></tr>
</table>

SESSION: 2 Investigate equivalent fractions used in contexts

<table>
<tr><th>WARM UP/IGNITION:</th><th>WORD PROBLEM:</th><th></th></tr>
<tr><td>Give out quarter pieces. How do we know they are quarters- through visualising? Students count by quarters beyond 1. Record on a class numberline. Revise mixed numerals.
http://www.bgfl.org/custom/resources_ftp/client_ftp/ks2/maths/fractions/
http://www.topmarks.co.uk/Flash.aspx?f=WhatFractionv3</td><td colspan="2">Jill is a marathon runner and trains for 4 ½ hours a week. How many hours will she train for over a month?</td></tr>
<tr><td>EXPLICIT TEACHING/MODELLING:</td><td>DIFFERENTIATION:</td><td>RESOURCES:</td></tr>
</table>

• Refer to mind map devised last term and revisit language and prior knowledge of fractions and decimals. • Introduce learning goal: Investigate equivalent fractions -Write on the board: 1/3. Revise the terms "denominator and numerator". Denominator as the number of equal parts a whole has been divided into, the numerator as the number of equal fractional parts, eg 38 means 3 equal parts of 8 -Use the example 1/3 = 2/6 with chocolate bar to model equivalence on the board. Repeat finding other equivalent fractions. -Use chocolate bar from previous lesson to model equivalent fractions on a class poster. -Demonstrate equivalent fractions using clear plastic cups and comparing capacity (1 full cup, 2 half cups, 4 quarter cups) Introduce the term 'PROPER FRACTION' – A fraction where the numerator is smaller than the denominator (and improper fraction- optional). * Using the fraction wall, demonstrate equivalent fractions. Discuss how multiples of numbers determines if a fraction is equivalent. * Write 1/3 on the board. Demonstrate how multiplying the numerator and the denominator by the same number will create an equivalent fraction (4/12). * Use the IWB (or make own) to use the fraction wall to display equivalent fractions. http://www.visnos.com/demos/fraction-wall	**EXTENSION:** Also work with fifths and tenths. **SUPPORT:** Work with halves and quarters.	A3 copy of equivalent fraction task
GUIDED/INDEPENDENT ACTIVITIES:	**EVALUATION/COMMENTS:**	
• Give each student an A3copy of A3 task to complete. **MATIFIC – SAME SAME 1** **https://www.matific.com/au/en-au/activity/BreadAndCheeseEquivalentFractionsEquivalent** **MATIFIC – SAME SAME 2** • **https://www.matific.com/au/en-au/activity/BreadAndCheeseEquivalentFractionsEquivalentToAThird**		
REFLECTION/WHERE TO NEXT:		
• Share with buddy two things that they know about fractions.		

SESSION: 3 ***Compare and describe equivalent fractions***

WARM UP/IGNITION:	**WORD PROBLEM:**	
• Practise counting by multiples of 3, 5 and 6. • http://www.turtlediary.com/grade-1-games/math-games/learn-fraction.html (basic revision)	Charlie, Dan, and Ellie each made a paper chain. Charlie's was 9 1⁄2 m long, Dan's was 6 1⁄2 m long, and Ellie's was 8 1⁄2 m long. End to end, how long were the three chains?	
MODELLED TEACHING	**DIFFERENTIATION:**	**RESOURCES:**

* Revise fraction terms: numerator, denominator and equivalent. *Count by quarters, halves and thirds, including with mixed numerals; locate and represent these fractions on a number line* Talk about how fractions are not all the same amount. They can be bigger or smaller than other fractions. The way to compare fractions is through diagrams and number lines focussing on the denominators. Show some examples e.g. 1/8 is less than 1/2 Focus on the denominator with unit fractions. MATIFIC – ALL THE SAME TO ME **https://www.matific.com/au/en-au/activity/NumberLineEquivalentFractionsSimpleFractions** MATIFIC – WHO GOT MORE CHEESE? **https://www.matific.com/au/en-au/activity/BreadAndCheeseComparisonComparison**	**EXTENSION:** **SUPPORT:**	Pack of Cards Whiteboards/Markers
GUIDED/INDEPENDENT ACTIVITIES:	**EVALUATION/COMMENTS:**	
* Write 1/3 on the board. Demonstrate how multiplying the numerator and the denominator by the same number will create an equivalent fraction (4/12). Display equivalent fractions using = with a diagram or numberline. Focus on denominators of 2, 4 and 8; 3 and 6; and 5, 10 and 100 * Use the IWB to use the fraction wall to display equivalent fractions. MATIFIC – ALL THE SAME TO ME **https://www.matific.com/au/en-au/activity/NumberLineEquivalentFractionsSimpleFractions** * Demonstrate comparing a fraction with another by using the symbols < > = (above grade level) MATIFIC – WHO GOT MORE CHEESE? **https://www.matific.com/au/en-au/activity/BreadAndCheeseComparisonComparison** * In pairs, students flip over two playing cards. The lowest number is placed above the other card to make a numerator and denominator. Draw the fraction and write it on a numberline. Repeat until each person has had 3 turns. Record on whiteboards to share with class during reflection. * Choose two fractions and compare by using the symbols < > or = on a post-it note (B-level assessment)		
REFLECTION/WHERE TO NEXT:		
• Share equivalent fractions with another pair and compare two fractions.		

SESSION: 4 ***Recognise that the place value system can be extended to tenths and hundredths, and make connections between fractions and decimal notation***

WARM UP/IGNITION:	**WORD PROBLEM:**	
Practise counting by multiples of 3, 5 and 6. On white boards students draw a number line from 0 to 5- call out fractions and students need to represent these in the correct place on their numberline. Talk about fractions that are equivalent and where they would be placed. http://www.visnos.com/demos/fraction-wall	McDonalds sell milkshakes in two sizes. A small milkshake contains 300ml and a large milkshake contains 2/3 more. (i) How much does a large milkshake contain? (ii) If Mr King drinks 2/3 of a small milkshake and Miss Smith 1/2 of a large milkshake who drinks the most?	
MODELLED TEACHING	**DIFFERENTIATION:**	**RESOURCES:**

*Draw a diagram to show that 1/2 is the same as 0.5 and 5/10. Use calculators and work out how to prove this. Draw them on a numberline. Talk about places you would see these fractions and decimals. *In a decimal number, the 2 places after the decimal point are tenths and hundredths. 2.15 has 2 wholes, one tenth and 2 hundredths. *just like in place value we can partition decimals. 5.37 = 5 + 3/10 + 7/100 *we can use non-standard partitioning as well. 5.37 = 5+37/100. Use a 100 MABs to show this. *money- 5 35/100 is the same as $5.35. 35 cents are not a whole dollar, they are a part, 35 hundreds. mathsonline- intro to decimals http://www.mathgoodies.com/lessons/decimals/introduction.html	**EXTENSION:** **SUPPORT:**	calculators MABs Whiteboards/Markers traffic light cups (red, orange, green)
GUIDED/INDEPENDENT ACTIVITIES:	**EVALUATION/COMMENTS:**	
Using 3 cards, make a number with a whole and 2 decimal places. Write it as a decimal then split it into whole plus tenths plus hundredths. Record in books.		
REFLECTION/WHERE TO NEXT:		
• Place traffic light cups on desk – red=help, orange= not sure, green= good to go		

WARM UP/IGNITION:	**WORD PROBLEM:**	
On a whiteboard record the equivalent fraction for 1/2 with a denominator of 4 and 8. Record the equivalent fraction for 1/3 with a denominator of 6. Do the same for denominators of 5, 10 and 100. Sit the class together and have them break into halves, halves again (quarters and keep going as far as possible. Picture book: The Lions Share	Last year, Mr Murrin weighed 60 kg. This year he weighs 2/5 more. How much does Mr Murrin weigh this year?	
MODELLED TEACHING	**DIFFERENTIATION:**	**RESOURCES:**
Measurements are recorded in decimals- 123cm =1.23m. 100cm= 1m, that's a whole. The 23cm are a part- 23/100 (or 2/10+ 3/100). 1000gm =1kg so 1400gms = 1.4kg, 500gms= 1/2 kg In reverse, 2.64m is 2 whole metres= 200 cm and 0.64 is a part of a metre=64cm- show using MABs 100 block. **MATIFIC -WEIGHING MATTERS** **https://www.matific.com/au/en-au/activity/WeighingMattersDecimalsExact** **MATIFIC -ONE IN A HUNDREDTH** **https://www.matific.com/au/en-au/activity/DecimalAdditionWithScalesWeigh**	**EXTENSION:** **SUPPORT:**	Picture book: The Lions Share MABs Whiteboards/Markers
GUIDED/INDEPENDENT ACTIVITIES:	**EVALUATION/COMMENTS:**	

MATIFIC -WEIGHING MATTERS **https://www.matific.com/au/en-au/activity/WeighingMattersDecimalsExact** **MATIFIC -ONE IN A HUNDREDTH** **https://www.matific.com/au/en-au/activity/DecimalAdditionWithScalesWeigh** **Give students amounts in m, cm, mm, Kg, gm and have them convert the amounts in books.**	
REFLECTION/WHERE TO NEXT:	
• Exit slip: How do you convert between mm, cm and m?	

Appendix 10: School D Pre- and Post-tests

MATIFIC PRE-TEST

YEAR 4 TERM 2 2016 NAME: _____ CLASS: _____

Maths Assessment – FRACTIONS AND DECIMALS

MA2-7NA – Represents, models and compares commonly used fractions and decimals.

1. Write the decimal for:

a. 9/10 _____ b. 1 8/10 _____

2. Use decimals to write:

a. 5 tenths _____ b. 8 tenths _____ c. 1 and 60 hundredths _____

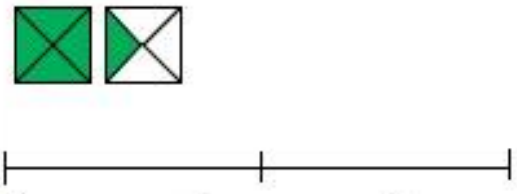
3. Write the equivalent fraction for:

a. $\frac{2}{8} = \frac{1}{\square}$	b. $\frac{50}{100} = \frac{\square}{2}$	c. $\frac{1}{4} = \frac{\square}{100}$	d. $\frac{2}{10} = \frac{\square}{5}$	e. $\frac{4}{5} = \frac{\square}{10}$

4. Display these fractions on the number line.

a. _____

b. _____



5. Write as centimetres

a. 50 mm _____ b. 4.85 m _____

6. Write as metres

a. 300 cm _____ b. 842 cm _____

7. Use greater than (>), less than (<) or equal to (=) to finish these equations.

Use the space below for working.

a. $\frac{1}{2} \square \frac{1}{6}$ b. $\frac{2}{8} \square$ c. $\frac{5}{10} \quad \frac{1}{2} \square$ d. $\frac{25}{100} \quad \frac{4}{10} \square$

MATIFIC POST-TEST

YEAR 4 TERM 2 2016 NAME: _____ CLASS: _____

Maths Assessment – FRACTIONS AND DECIMALS

MA2-7NA – Represents, models and compares commonly used fractions and decimals.

1. Write the decimal for:

a. 7/10 _____ b. 1 5/10 _____

2. Use decimals to write:

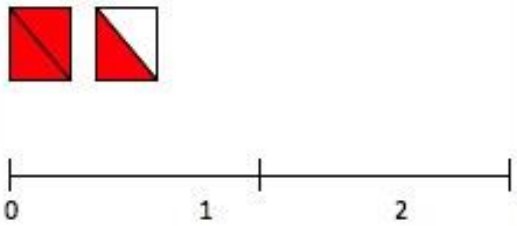
a. 3 tenths _____ b. 9 tenths _____ c. 1 and 70 hundredths _____

3. Write the equivalent fraction for:

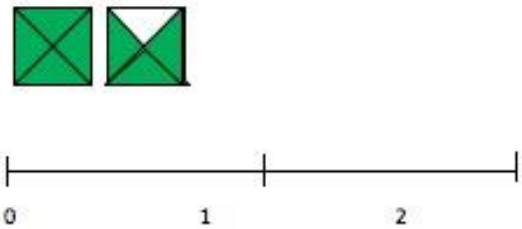
a. $\frac{1}{4} = \frac{2}{\square}$	b. $\frac{40}{100} = \frac{\square}{10}$	c. $\frac{3}{4} = \frac{\square}{100}$	d. $\frac{4}{10} = \frac{\square}{5}$	e. $\frac{3}{5} = \frac{\square}{10}$

4. Display these fractions on the number line.

a. _____



b. _____



5. Write as centimetres

a. 70 mm _____ b. 2.95 m _____

6. Write as metres

a. 400 cm _____ b. 912 cm _____

7. Use greater than (>), less than (<) or equal to (=) to finish these equations.

Use the space below for working.

a. $\frac{1}{2} \square \frac{5}{8}$ b. $\frac{1}{6} \square \frac{1}{8}$ c. $\frac{2}{5} \square \frac{4}{10}$ d. $\frac{25}{100} \square \frac{8}{10}$

Appendix 11: School E Unit of Work

Year Six – 2016

STAGE:				CONTENT STRAND	TERM:				DURATION									
ES1	S1	S2	S3	*NUMBER*	1	2	3	4	1	2	3	4	5	6	7	8	9	10

"The Four Operations"

RATIONALE:

Mathematics is a dynamic science which empowers individuals to become effective members of society. It provides a framework for the analysis of problems and the development of appropriate solutions, from the most basic to those which are quite complex.

Throughout this unit students will

- select and apply appropriate mental, written or calculator strategies for the four operations and check the reasonableness of answers using estimation.
- solve word problems and apply the order of operations to number sentences where required.
- identify factors and multiples and recognise the properties of prime, composite, square and triangular numbers.
-

The nature of mathematical experiences that are undertaken enable students to see the relevance of school mathematics in many aspects of their everyday life.

(PLC) ESSENTIAL LEARNING GOAL:	***SMART GOAL:***	***OUTCOMES:***
• Apply an understanding of the relationships between the four operations • Explore the use of brackets and the order of operations to write number sentences • Complete an extended multiplication operation and a contracted division that includes an internal zero	***80%***	**MA3-6NA** - selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation **MA3-3WM** - gives a valid reason for supporting one possible solution over another

SPECIFIC LANGUAGE	***RESOURCES***
Students should be able to communicate using the following language: multiply, multiplied by, product, multiplication, multiplication facts, area, thousands, hundreds, tens, ones, double, multiple, factor, divide, divided by, quotient, division, halve, remainder, fraction, decimal, equals, strategy, digit, estimate, **speed**, **per**, **operations**, **order of operations**, **grouping symbols**, **brackets**, **number sentence**, is the same as, **parentheses**.	"Matific" online resource - https://www.matific.com/au/en-au/ Mathematics Journals

STAGE				**CONTENT STRAND**	*TERM*				*WEEK*									
ES1	*S1*	*S2*	*S3*	*NUMBER*	*1*	*2*	*3*	*4*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

(PLC) ESSENTIAL LEARNING GOAL:	***SMART GOAL:***	***OUTCOMES:***
• Apply an understanding of the relationships between the four operations • Explore the use of brackets and the order of operations to write number sentences • Complete an extended multiplication operation and a contracted division that includes an internal zero	***80%***	**MA3-6NA** - selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation **MA3-3WM** - gives a valid reason for supporting one possible solution over another

CONTENT	***TEACHING AND LEARNING ACTIVITIES***	**DIFFERENTIATED ACTIVITIES**	**RESOURCES**
Students: Select and apply efficient mental and written strategies, and appropriate digital technologies, to solve problems involving multiplication and division with whole numbers and applies the order of operations to calculations involving more than one operation • select and use efficient mental and written strategies, and digital technologies, to multiply whole numbers of up to four digits by one- and two-digit numbers	**Lesson One**: PRETEST 60mins • Introduce Matific **Lesson Two**: Explore Multiplication • Language and terminology of multiplication • Mental computation of multiplication Multiplication • Introduce Area Model for solving multiplication • Matific Resource - Expanded Algorithm • Revise standard Algorithm technique • Matific Resource - Standard Algorithm	**Support:** Balancing Act – Level I **Extension:** Balancing Act – Level III	Balancing Act **HW** Ask a Monster Multiplication Algorithms Expanded Algorithm Extended-to-Standard Algorithm **HW** Standard Algorithm Feed the Lions

EVALUATION

STAGE				**CONTENT STRAND**	*TERM*				*DURATION*									
ES1	*S1*	*S2*	*S3*	*NUMBER*	*1*	*2*	*3*	*4*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

(PLC) ESSENTIAL LEARNING GOAL:	***SMART GOAL:***	***OUTCOMES:***
• Apply an understanding of the relationships between the four operations • Explore the use of brackets and the order of operations to write number sentences • Complete an extended multiplication operation and a contracted division that includes an internal zero	***80%***	**MA3-6NA** - selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation **MA3-3WM** - gives a valid reason for supporting one possible solution over another

CONTENT	***TEACHING AND LEARNING ACTIVITIES***	**DIFFERENTIATED ACTIVITIES**	**RESOURCES**
• select and use efficient mental and written strategies, and digital technologies, to divide whole numbers of up to four digits by one- and two-digit numbers	**Lesson Three**: Multiplication • Introduce Area Model for solving Expanded Multiplication • Matific Resource - Expanded Algorithm • In Mathematics Journals investigate Expanded Multiplication Algorithms identifying – language - presentation - understanding the purpose and function of "the zero" • Justification of answer and method **Lesson Four**: Division Revision • Division Language and terminology of division • Mental computation of division • Matific Resource – Got to Split • Explore skill involved with estimation • Mental computation and estimation of division Matific Resource – Somewhere Along the Line	**Support:** Deene's Blocks for concrete material **Extension:**	Multiplication Algorithms Expanded Algorithm HW Maths worksheet: Properties of Multiplication Distributive Property Got to Split Somewhere Along the Line HW Maths worksheet: Properties of Division **Distributive Property**

EVALUATION

STAGE				**CONTENT STRAND**	*TERM*				*DURATION*									
ES1	*S1*	*S2*	*S3*	*NUMBER*	*1*	*2*	*3*	*4*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

(PLC) ESSENTIAL LEARNING GOAL:	***SMART GOAL:***	***OUTCOMES:***
• Apply an understanding of the relationships between the four operations • Explore the use of brackets and the order of operations to write number sentences • Complete an extended multiplication operation and a contracted division that includes an internal zero	***80%***	**MA3-6NA** - selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation **MA3-3WM** - gives a valid reason for supporting one possible solution over another

CONTENT	***TEACHING AND LEARNING ACTIVITIES***	**DIFFERENTIATED ACTIVITIES**	**RESOURCES**
• select and use efficient mental and written strategies, and digital technologies, to apply the order of operations to calculations involving more than one operation	**Lesson Five**: Division • Algorithms identifying – language - presentation - understanding the purpose and function of "the zero" • Justification of answer and method **Lesson Six**: Order of Operation • identifying – language - presentation - understanding the purpose and function of "the zero" Matific Resource – Order of Operation Four Operations Game Level II • Justification of answer and method	**Support:** Four Operations Game Level I **Extension:** Four Operations Game Level III	**HW** Somewhere Along the Line Four Operations Game HW A Balancing Act Level I - III

EVALUATION

STAGE				**CONTENT STRAND**	*TERM*				*DURATION*									
ES1	***S1***	***S2***	***S3***	*NUMBER*	***1***	***2***	***3***	***4***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

(PLC) ESSENTIAL LEARNING GOAL:	***SMART GOAL:***	***OUTCOMES:***
• Apply an understanding of the relationships between the four operations • Explore the use of brackets and the order of operations to write number sentences • Complete an extended multiplication operation and a contracted division that includes an internal zero	***80%***	**MA3-6NA** - selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation **MA3-3WM** - gives a valid reason for supporting one possible solution over another

CONTENT	***TEACHING AND LEARNING ACTIVITIES***	**DIFFERENTIATED ACTIVITIES**	**RESOURCES**
• select and use efficient mental and written strategies, and digital technologies, to apply the order of operations to calculations involving more than one operation, including parentheses decimals and numbers to the power of '?'	**Lesson Seven**: Order of Operation • Revising - language - presentation - understanding the purpose and function of "the zero" • Introduce Order of Operation and parentheses • Matific Resource - Order of Operation Four Operations - Order of Operation Parentheses **Lesson Eight**: Order of Operation • Revising - language - presentation - understanding the purpose and function of "the zero" - Order of Operation and parentheses • Introduce decimals and numbers to the power of '?' • Matific Resource - Order of Operation Decimals - Order of Operation Expert	**Support:** Four Operations Game Level I **Extension:** Four Operations Game Level III	**HW** Somewhere Along the Line Four Operations Game Order of Operation Parentheses Order of Operation Decimals Order of Operation Expert HW A Balancing Act Level I – III Order of Operation Parentheses

EVALUATION

STAGE				**CONTENT STRAND**	*TERM*				*DURATION*									
ES1	*S1*	*S2*	*S3*	*NUMBER*	*1*	*2*	*3*	*4*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

(PLC) ESSENTIAL LEARNING GOAL:	***SMART GOAL:***	***OUTCOMES:***
• Apply an understanding of the relationships between the four operations • Explore the use of brackets and the order of operations to write number sentences • Complete an extended multiplication operation and a contracted division that includes an internal zero	***80%***	**MA3-6NA** - selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation **MA3-3WM** - gives a valid reason for supporting one possible solution over another

CONTENT	***TEACHING AND LEARNING ACTIVITIES***	**DIFFERENTIATED ACTIVITIES**	**RESOURCES**
	Lesson Nine: Unit Revision Based on gathered student data, revise/extend the topics and/or skills that require attention. • Revising Multiplication, Division and Order of operation - language - presentation - understanding the purpose and function of "the zero" - Justification of answers and method **Lesson Ten**: Post Assessment	**Support:** Four Operations Game Level I **Extension:** Four Operations Game Level III	**HW** Somewhere Along the Line Four Operations Game HW A Balancing Act Level I - III

EVALUATION

Appendix 12: School E Pre- and Post-tests

Matific Research Project
Multiplication and Order of Operation
Pre Test

- Apply an understanding of the relationships between the four operations
- Explore the use of brackets and the order of operations to write number sentences
- Complete an extended multiplication operation and a contracted division that includes an internal zero

Questions

1. Kathy and Bob needed to estimate an answer in their test if the question is 24 490 ÷ 80 = Who has estimated correctly?
Kathy a) 3000
Bob b) 300
Justify your answer (Why?)

_____

_____

2. Kathy and Bob also needed to estimate an answer for the question is 768 ÷ 3 = who is has the most effective estimate?
Kathy a) 2400
Bob b) 2100
Justify your answer (Why?)

_____

_____

3. a)James has 15 986 roses if there are 4 colours, estimate how many roses of each colour James has?

b) Justify your answer (Why?)

_____

_____

4. There are 5 paddocks each containing 125 sheep farmer Borris counted his sheep by adding each paddock together. 125 + 125 + 125 + 125 + 125 = _____.
a) How else could he have calculated the total number of sheep? Please show your working.

b) Bob divided two numbers and the answer was 86. What could the two numbers be?

c) If one of the numbers is a four digit number what could the two numbers be?

5.
$$\begin{array}{r} {}^{1}\,5\,9\,{}^{1}0\,6\,3 + \\ 4\,6\,5\,6\,9 \\ \hline 1\,0\,5\,6\,2\,2 \end{array}$$

Your calculator is broken how could you see if your answer in correct?

6. The answer to a question is 48; provide questions using the four operations

7. Answer the following question

a) 16 + 5 x 7=

b) 5 x 7 + 16=

c) (14 + 6) ÷ 5 =

d) (25 + 3) – 5 x 4=

8. Place brackets to make the following correct

a) 3 x 4 + 5 x 4 – 2 = 22

b) 3 x 4 + 5 x 4 – 2 = 54

9. Answer the following questions

a) 14 089 x 56=

b) 90 806 x 48=

10. Answer the following division questions

a) Please show any remainders as a fraction

1805 ÷ 6

b) Please show any remainders as a decimal

1605 ÷ 8

Matific Research Project
Multiplication, Division and Order of Operation
Post-Test

- Apply an understanding of the relationships between the four operations
- Explore the use of brackets and the order of operations to write number sentences
- Complete an extended multiplication operation and a contracted division that includes an internal zero

Questions

1. Kathy and Bob needed to estimate an answer in their test if the question is 59 490 ÷ 30 = Who has estimated correctly?
Kathy a) 20 000
Bob b) 2 000
Justify your answer (Why?)

_____

_____

2. Kathy and Bob also needed to estimate an answer for the question is 59 634 x 55 = who is has the most effective estimate?
Kathy a) 3 000 000
Bob b) 3 300 000
Justify your answer (Why?)

_____

_____

3. a) James has 35 986 roses if there are 6 colours, estimate how many roses of each colour James has?

b) Justify your answer (Why?)

_____

_____

4. There are 7 paddocks each containing 175 sheep farmer Borris counted his sheep by adding each paddock together. 175 + 175 + 175 + 175 + 175 + 175 + 175 = _____.
a) How else could he have calculated the total number of sheep? Please show your working.

b) Kerry divided two numbers and the answer was 86. What could the two numbers be?

c) If one of the numbers is a four digit number what could the two numbers be?

5. $\begin{array}{r} {}^{3}\not{5}{}^{1}\not{4}6\,063 \\ -\ 349\,569 \\ \hline 217\,506 \end{array}$

Your calculator is broken, show how you could see if your answer is correct? Justify your process.

6. The answer to a question is 56; provide a question using the four operations

7. Answer the following question

a) 16 - 8 x 7=

b) 8 x 7 - 16=

c) (6 + 6) x 12 =

d) $(25 + 3^2) – 5 \times 4=$

8. Place brackets to make the following correct

a) 13 + 25 ÷ 5 + 6 x 2 = 35

b) 13 + 25 ÷ 5 + 6 x 2 = 30

9. Answer the following questions

a) 46 009 x 56=

b) 907 806 x 73=

10. Answer the following division questions
a) Please show any remainders as a fraction
91 438 ÷ 7

b) Please show any remainders as a decimal
68 065 ÷ 8

Appendix 13: School F Unit of Work

<table>
<tr><td colspan="4">FRACTIONS & DECIMALS</td></tr>
<tr><td>Teachers:</td><td>Stage: 3
Grade: Year 5 and 6
Duration: Term 3/ Weeks 1-3</td><td>Mathematics
Strand: Number
Substrand: Fractions and Decimals 2</td><td>Outcomes:
MA3-1WM; MA3-2WM; MA3-3WM; MA3-7NA</td></tr>
<tr><td colspan="4">Content:
recognise that place value system extends beyond hundredths
compare, order and represent decimals
add and subtract decimals, with and without the use of digital technologies, and use estimation and rounding to check the reasonableness of answers
Multiply decimals by whole numbers and perform division by on-zero whole numbers where the results are terminating decimals, with and without the use of digital technologies
Make connections between equivalent fractions, decimals and percentages</td></tr>
<tr><td>Planned Assessment:
Students will be pre- and post-tested using teacher made assessments.</td><td>Curriculum Differentiation:
Students will be ability grouped across the grades following the pre-test.</td><td colspan="2">Warm Up activities:
https://www.matific.com/au/en-au/activity/MultiplicationTableUpTo10https://www.matific.com/au/en-au/activity/MultiplicationTableUpTo10
https://www.matific.com/au/en-au/activity/MultiplicationByTruckTenshttps://www.matific.com/au/en-au/activity/MultiplicationByTruckTens
https://www.matific.com/au/en-au/activity/GraphingRecipeRatiosTablehttps://www.matific.com/au/en-au/activity/GraphingRecipeRatiosTable
https://www.matific.com/au/en-au/activity/SequenceWithBricksRatiohttps://www.matific.com/au/en-au/activity/SequenceWithBricksRatio</td></tr>
<tr><td colspan="4">Teaching and Learning Sequence:</td></tr>
</table>

DAY 1

Learning goal: By the end of this lesson, I will be able to convert tenths and hundredths to decimal numbers and back again

Modelled Teaching:

Regrouping tenths, hundredths and thousandths/reading and writing thousandths:

Revise decimal place value with students e.g.

(tenths, hundredths, thousandths, ten thousandths columns etc)

On the board, draw a 2 metre line and ask: how long is this line in metres? Decimetres or tenths of a metre? Centimetres or hundredths of a metre? Millimetres or thousandths of a metre? Write the following sentences on the board and invite students to complete them:

The line is 2 metres long.
The line is ___ decimeters long.
The line is ___tenths of a metre long.
The line is ___ centimetres long.
The line is __ hundredths of a metre long.
The line is ___ millimetres long.
The line is ___ thousandths of a metre long.

Erase the numbers and show the students a decimal numeral expander (in resources). Demonstrate the relationship above using the numeral expander. Use the numeral expander to find the equivalent lengths to a) 25 tenths of a metre and b) 350 hundredths of a metre. (write in sentences as shown above. E.g. the line is _).

Guided teaching:

Draw the number line shown below and label as shown.

Ask: where do you think I have drawn the arrows? How do you know? Explanations might include: 'the second arrow is a little more than one. So it could be 1.1. if it is a little less than one tenth more, It could be 1.08'. etc

Write the number 'one and three hundred and five thousandths on the board and invite students to draw the arrow to that point. Use the expander to review writing the number and then record the value above the arrow. Repeat for: one and six thousandths, sixteen thousandths, and one and six hundredths.

Practice regrouping and showing equivalent fractions e.g. 5 ones = 50 tenths = 500 hundredths = 5000 thousandths write numbers in decimal form on the board. Have students write the number in words e.g. 0.14 = fourteen hundredths.

Independent Activity:

Dice game: in pairs, students roll 2 or 3 dice and try to make the smallest decimal number possible. Eg roll 2, 8, make the number 0.28 or roll 7,6,4 make the number 0.476. The student records their number on their whiteboard. The second student then rolls their dice to make the smallest number possible and records it. The first student then rolls again, makes their number and adds it to their first number. The second student checks their addition with a calculator and corrections made if necessary. The turns continue until one player has a total equal to or greater than 10. This player loses that game.

Extension: students roll one dice at a time and must make a decision about where that number is placed before rolling their second or third dice. This introduces an element of probability to the game. Eg student rolls a 7 and must decide whether to place in the tenths, hundredths or thousandths column before rolling the next die.

Reflection: Where have I seen this before? Where could this be used in the world? What have I learned today? What did I like about the activity?

DAY 2

Learning Goal: by the end of this lesson, I will be able to locate thousandths on a number line

Guided teaching:

Working with relative position and locating thousandths on a number line:

On the board, draw a number line and mark points 2.5, 2.6, 2.7, 2.8, and 2.9 with equal distance. Ask: how has this number line been divided? (tenths). Draw an arrow anywhere between 2.7 and 2.8 and ask: what number do you think is located here? How do you know? Discuss reasoning e.g. the arrow is closer to 2.8 than 2.7, it is more than 2.75 etc).

Ask how far away is the number from the tenth that is nearest? Have students use a strategy involving jumps on the number line to figure out the difference.

Replace the numbers under the number line with 5, 6, 7, 8 and 9. Write 7.64 on the board and ask a volunteer to mark its position on the line. Ask students to identify the whole number it is closest to and the distance from 7.64 to that number. Repeat for 7.46 and other decimal numbers found on the line.

Direct students to work in groups to very accurately cut lengths of string to match their arm spans from fingertip to fingertip. They then measure the string and record measurements to the nearest thousandth of a metre. Draw a 2 metre number line on the board from 0m to 2m marking only the 0m, 1m and 2m marks. Ask students to mark the lengths on the line.

Get students to write numbers that are one thousandth more and one thousandth less than the arm spans recorded.

Differentiated Group activities: 15 minute rotations

Group 1: https://www.matific.com/au/en-au/search One in a hundredth.

Group 2: Card decimals. Using a blackline master with playing card spaces showing two places before and three places after the decimal point, students deal 5 cards to each player. Students make the largest numbers they can. They estimate then calculate the difference between their number and the next whole number. One student does the calculation manually and the other checks with a calculator. Eg player makes the number 24.586 then must calculate 25-24.586 to get the answer 0.414. how close was the estimation? What do they notice about calculating the difference?

Group 3: decimal worksheet hundredths

Reflection Questions:

What mathematics were you investigating?

What questions arose while you worked?

What changes did you have to make to solve the problem?

What was the most challenging part of the task and why?

DAY 3

Learning goal: by the end of this lesson, I will be able to put numbers involving tenths and hundredths in order.

On the board draw a number line and label it with 3,4 and 5. Ask what place would you look at first, second and third, to decide where to position the following numbers 3.28 and 4.65 what can we say about these numbers? Eg 3.28 <4.65. Get students to rule a 10cm square grid and complete the hundredths chart. Ask students to underline 0.42. What number is in the square above and below. How do you know? Discuss the fact that the decimal above and below is one tenth less and one tenth more. Draw a section of a grid and write in one number, ask students to record the missing numbers around that number.

In pairs, students draw a section of a hundred chart and give to their partner to solve using whiteboards. Students can use their hundredth chart to check their partner's answers.

Write a variety of numbers on the board and have students practice ordering them from smallest to largest and largest to smallest

Individual activity: worksheet 'comparing decimals' (matific)

Reflection Questions:

What does this make you think of?
What other mathematics can you you connect this with?
Where do you see_____ at home? At school? In other places?
How is this like something you have done before?

DAY 4

Learning goal: by the end of this lesson, I will be able to round numbers to the nearest tenth, hundredth and thousandth

Revise rounding numbers to the nearest 10, hundred etc.
Explain and model using the digit directly to the right of the one you want to round off to determine whether to round up or down, and dropping all digits to the right of it.

Group 1: https://www.matific.com/au/en-au/activity/WeighingMattersDecimalsRound Students play 'weighing matters – round decimals'
Group 2: students roll 4 dice to make a 4 digit decimal number. They then write onto their whiteboard and use a random spinner to determine whether they have to round off to tenths, hundredths or thousandths. The player with the highest number wins.
Group 3: decimal rounding worksheet

Reflection Questions:

How did you solve the problem?
What did you do?
What strategy did you use?
What maths words did you use or learn?
What were the steps involved?

What did you learn today?

DAY 5

Learning goal: by the end of this lesson, I will be able to convert fractions to decimals with 2 decimal places
(matific lesson plan)

https://www.matific.com/au/en-au/resources/LessonPlans/6G?episode=LPFractionToDecimal2DecimalPlaces

Students play the following activity.
https://www.matific.com/us/en-us/activity/FractionsAndDecimals2Digit

Students complete activity on lesson plan. They colour squares to represent fractions, tenths and hundredths. They then convert them into decimals.

Closure:
Teacher asks students: 0.5, 0.50,0.05
Ask: Which number does not belong? How do you know?
0.05 does not belong. All the other numbers are equal to one half, but 0.05 is five hundredths, also known as one twentieth.
Teacher gives other examples and then asks reflection questions.
Reflection Questions:
What else would you like to find out about_____?
How do you feel about Mathematics?
What does the maths remind you of?https://www.matific.com/au/en-au/resources/LessonPlans/6G?episode=LPFractionToDecimal2DecimalPlaces

DAY 6

Learning goal: by the end of this lesson, I will be able to convert fractions to decimals with 3 decimal places
Matific lesson: converting fractions to decimals – 3 decimal places
Teacher explicitly teaches how to convert fractions to 3 decimal places. For example; 4

$$500 = 4 \div 500 = 0.008$$

https://www.matific.com/au/en-au/resources/LessonPlans/6G?episode=LPFractiontoDecimal3DecimalPlaces

Students complete the activity:
https://www.matific.com/undefined/undefined/activity/FractionsAndDecimals3Digit
Group 1: work individually

Group 2: work in pairs to complete the activity.
Group 3: Complete a teacher made worksheet using the assistance of a calculator.

Reflection Questions:
The thing I liked best about mathematics today was …
The hardest part of mathematics today ____ was…
This Mathematics is like … because…
https://www.matific.com/au/en-au/resources/LessonPlans/6G?episode=LPFractiontoDecimal3DecimalPlaces

DAY 7
Learning goal: by the end of this lesson, I will be able to add decimals with different numbers of digits

Write a group of decimals on the board with differing numbers of digits eg 4.8; 3.07; 1.22; 8.085 ask students how would they go about adding these numbers
Demonstrate how to use a grid book to correctly set out the addition algorithm. Remind students that putting in zeros after the decimal point to 'hold' places will make no difference to the number eg 3.07 and 3.070 are the same number.
Group 1: Students use random number generators to make up their own decimal additions and complete in pairs with one student using a calculator to check answers. Once students are confident adding mixes of one and two decimal places, they can add numbers with 3 decimal places.
Group 2: students complete episode 'decimal addition'
Group 3: students complete worksheet on decimal addition
Reflection Questions:
How did you solve the problem?
What did you do?
What strategy did you use?
What maths words did you use or learn?
What were the steps involved?
What did you learn today?

DAY 8

Learning goal: by the end of this lesson, I will be able to subtract decimal numbers

Write a pair of decimal numbers on the board with different numbers of digits eg 4.67 and 3.9. Ask what could these numbers represent? Which number is larger? How would we find the difference?

Demonstrate how to use a grid book to correctly set out the subtraction algorithm. Remind students that putting in zeros after the decimal point to 'hold' places will make no difference to the number eg 3.07 and 3.070 are the same number.

Ask students to estimate the answer to the algorithm 4.67 – 3.9=

Demonstrate how to work the algorithm manually and with a calculator.

Students use random number generators to make up their own decimal additions and complete in pairs with one student using a calculator to check answers.

Students complete worksheet on subtraction with money.

Reflection Questions:

I solved the problem by…

The maths words i used were…

The steps i followed were…

DAY 9:

Learning goal: by the end of this lesson, I will be able to multiply decimals by whole numbers and by other decimals

Explicit teaching: Multiplying a decimal by a single digit.

For example; 42.2 x 4= 168.8

When multiplying a decimal ignore the decimal point and multiply the digits. Then count the decimal points in the question. There is one in this question. Teacher does the same for numbers with two decimal places .For example 24.31 x5= 121.55 there are two decimal places.

Teacher explains how to multiply decimals by other decimals. For example 2.2 x 1.7=3.74

2.2 has 1 decimal digit

1.7 has 1 decimal digit

The answer then has 2 decimal digits= 3.71

Independent Activity: Students complete the following activity on matific

https://www.matific.com/au/en-au/activity/EstimatingDecimalsMultiplicationOnTheNumberLineTwoDecimalPlaces

In pairs, students randomly give their partner a problem involving the multiplication of a decimal by a single digit. The partner writes the sum down and verbally estimates it and then works it out. Then swaps with their partner and so on.

Reflection Questions:

How did you solve the problems?

What did you do?
What strategy did you use?
What maths words did you use or learn?
What were the steps involved?
What did you learn today?

DAY 10:
Learning goal: by the end of this lesson, Students will solve word problems involving the addition and subtraction of decimals.

Independent Activity: Students complete the following activity on matific
https://www.matific.com/au/en-au/activity/ShopAdditionDecimalsSimple (low ability)

https://www.matific.com/au/en-au/activity/ShopAdditionDecimals (middle ability)

Students are given word problems involving the addition and subtraction of decimals.
Reflection Questions:
How did you solve the problem?
What did you do?
What strategy did you use?
What maths words did you use or learn?
What were the steps involved?
What did you learn today?

DAY 11:
Learning goal: by the end of this lesson, Students will solve word problems involving the multiplication and division of decimals.
Teacher demonstrates how to multiply and divide decimals using the powers of 10. Class completes some questions using the division and multiplication of decimals by powers of 10 (in mixed ability pairs).
Independent Activity: Students complete the following activity on matific
Students are given word problems involving the multiplication and division of decimals (Levelled).
Reflection Questions:
How did you solve the problem?
What did you do?
What strategy did you use?
What maths words did you use or learn?

Appendix 14: School F Pre- and Post-tests

Stage 3

Fractions and Decimals pre-test

1. Express the following thousandths as decimals.
   a) $\frac{24}{1000}$ = b) $\frac{55}{1000}$ = c) $\frac{234}{1000}$ = d) $\frac{678}{1000}$ =

2. Express the following decimals as thousandths.
   a) 0.125 = b) 0.457 = c) 0.897= d) 0.345=

3. Calculate 67750 grams to kilograms showing three decimal places.

   _____

4. Calculate the 175 cm to metres showing three decimals places.

   _____

5. Order the following decimals from smallest to largest.

   0.5, 0.750, 0.225, 0.35, 2.456, 0.3

   _____, _____, _____, _____, _____, _____,

6. Plot the following decimals on a numbers on a number line.

   0.2, 0.30, 0.10, 0.7, 0.65, 0.170, 0.90

Work out the following problems.

7) 2.5 × 3x = _____ _____

8) 1.7 × 2x = _____ _____

9) 6.4 × 3x = _____ _____

10) I have 3 boxes. Each box was 2.35cm in length. What is the total length of all my boxes?	11) I had 10.25kg of rice. I shared the rice with 5 people. How much rice did each person receive?

12) Tom paid $7710 of rent for 5 months. How much rent did he pay a month?	13) A company gave $80.20 to each of their 36 employees. How much money did the company give out to the employees' altogether?

14) Calculate the following multiplications.

a) 0.76 × 100 = _____

b) 0.452 × 10 = _____

c) 0.952 × 1000 = _____

15) Divide the following decimals.

a) 7.56 ÷ 100= b) 5.25÷10= c) 2.250 ÷ 1000=

16. Write down everything you know about these decimals.

0.25	**0.125**

Post-Test

Stage 3

Fractions and Decimals post-test

1. Express the following thousandths as decimals.

a) $\frac{34}{1000} = 0.034$ ✓ b) $\frac{75}{1000} = 0.075$ ✓ c) $\frac{936}{1000} = 0.936$ ✓ d) $\frac{579}{1000} = 0.579$ ✓ 4

2. Express the following decimals as thousandths.

a) $0.895 = \frac{895}{1000}$ ✓ b) $0.285 = \frac{285}{1000}$ ✓ c) $0.783 = \frac{783}{1000}$ ✓ d) $0.287 = \frac{287}{1000}$ ✓ 4

3. Calculate 48850 grams to kilograms showing three decimal places.

48.850 kg ✓ 1

4. Calculate the 134 cm to metres showing three decimals places.

1.34m ✓ 1

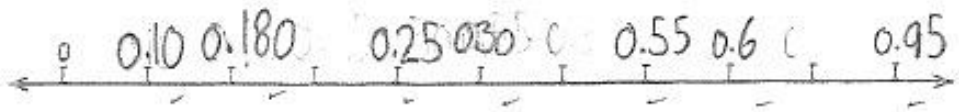
5. Order the following decimals from smallest to largest.

0.5, 0.650, 0.225, 0.20, 2.145, 0.4

0.20, 0.225, 0.4, 0.5, 0.650, 2.145 ✓ 1

6. Plot the following decimals on a numbers on a number line.

0.25, 0.30, 0.10, 0.6, 0.55, 0.180, 0.95



✓ 1

Work out the following problems.

7) 5 3.5
3x
14.1
10.5

8) 1.5
2x
3.0 ✓

9) 3.2
3x
9.6 ✓ 2

Show your work.

10) I have 4 boxes. Each box was 6.45cm in length. What is the total length of all my boxes?

25.80cm ✓

2

11) I had 12.60kg of rice. I shared the rice with 6 people. How much rice did each person receive?

1.10 kg

2.1 kg

12) Tom paid $6510 of rent for 4 months. How much rent did he pay a month?

$25040

1627r2

$1627.50

13) A company gave $90.10 to each of their 42 employees. How much money did the company give out to the employees' altogether?

$3600.10

3784.20

14) Calculate the following multiplications. Move decimal right →

a) 0.54 (100x) 54.00 ✓

b) 0.256 (10x) 2.560 2.56

c) 0.834 (1000x) 834.000 ✓

2

15) Divide the following decimals. Move decimal Left ←

a) 4.98 ÷ 100= 252 0.0498 (add zero place holder)

b) 6.24 ÷10= 1.9

c) 1.150 ÷ 1000= 1.150

16. Write down everything you know about these decimals.

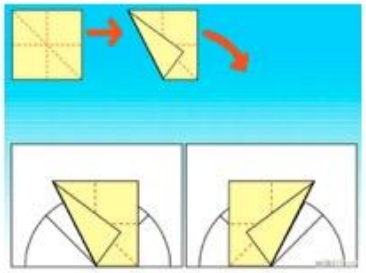
0.15	0.135
0.15 ✓ $\frac{15}{100} = 0.15$ ✓ 2	0.135 ✓ $\frac{135}{1000} = 0.135$ ✓ 2

Appendix 15: School G Unit of Work

STAGE:				CONTENT STRAND	TERM:				DURATION									
ES1	S1	S2	S3	• Measurement and Geometry - Angles 1	1	2	3	4	1	2	3	4	5	6	7	8	9	10

RATIONALE:

ESSENTIAL LEARNING GOAL:	***SMART GOAL:***	***OUTCOMES:***
Students will be able to; - estimate, measure and compare angles using degrees - construct angles using a protractor	***Matific Resource 90%***	**MA3-1WM** describes and represents mathematical situations in a variety of ways using mathematical terminology and some conventions **MA3-16MG** measures and constructs angles, and applies angle relationships to find unknown angles

CONTENT	***TEACHING AND LEARNING ACTIVITIES***	**DIFFERENTIATED ACTIVITIES**	**RESOURCES**
• Estimate, measure and compare angles using degrees (ACMMG112)	1 Sts experiment by making a protractor. 		Matfic – Episode 1 Know all the angles -ipads https://www.matific.com/au/en-au/grades/5G/Measurements/Angles Episode 2 Know all the angles https://www.matific.com/au/en-au/activity/AddingAndSubtractingAnglesSubtract Episode 3 Adding and Subtracting angles https://www.matific.com/au/en-au/activity/AddingAndSubtractingAnglesAddAndSubtract
identify the arms and vertex of an angle where both arms are invisible, such as for rotations and rebounds record angle measurements using the symbol for degrees (°) recognise the need for a formal unit for the	2. A small goal is created on an asphalt area using witches' hats. Students place a ball in front of the goal. They draw the angle created in chalk on the asphalt, using the ball as the vertex and the goal posts as the ends of the arms. They then measure and record the angle created, using the teacher's protractor. Students try to score a goal from that position. Students repeat the activity from other positions in front of the goal, drawing, measuring and recording the angle created in each new position. Possible questions include: • Where were the angles smaller? Why? • How did the size of the angle affect the ease of scoring a goal? Why? • If you moved the ball closer or further away from the goal line, did it change the size of the angle? How? Why? • How would the presence of a goal-keeper affect the angles created?		

measurement of angles measure angles of up to 360° using a protractor • Construct angles using a protractor (ACMMG112)	**Angles in the Environment** Students identify, record and classify angles in the environment using the terms 'right', 'acute', 'obtuse', 'straight', 'reflex' and 'revolution' Students collect a variety of pictures that show various angles eg buildings, football fields, aerial views. They identify angles in the pictures Possible questions include: • What strategies did you use to describe your angles? • Did you discover anything about the type of angles identified? *Variation:* Students measure the angles traced and record their finding **Constructing Angles** In pairs, students draw ten different angles for each other. Students then measure, label and order their partner's drawings. ***Toothpick angles*** *– sts construct angles using toothpicks and label.* **Drawing Triangles:** Give students a description of different triangles and ask them to draw, name and label different triangles (right angled, equilateral, isosceles and scalene). **Angling** Sts draw a robot, boat, building with a range of different angles (ie: acute, obtuse, reflex, etc. have sts identify different types of angles they used.	-Sts record kicks on an ipad and identify angles by drawing the angles on the photo.	Episode 4 Parts of a circle https://www.matific.com/au/en-au/activity/AnglesAsCircularSectorsSectors Episode 5 What's your angle https://www.matific.com/au/en-au/activity/AnglesAsCircularSectorsAcuteRightObtuse Protractor Toothpicks Matfic – Episode Using the protractor 6 https://www.matific.com/au/en-au/activity/MeasuringWithProtractorAngles Protractors Protractors Episode 7 https://www.matific.com/au/en-au/activity/MeasuringWithProtractorTriangles
EVALUATION Students made significant improvements from pre test to post test. They enjoyed the Matific episodes as it was engaging and positive. Some of the activities were hard to complete due to lack of instructions. Some of the content such as naming angles was not addressed. The use of the protractor was great as students practised how to use a protractor in a fun way.			

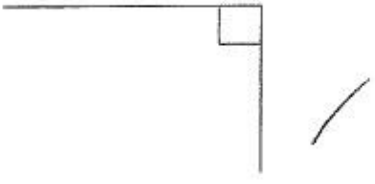
Appendix 16: School G Pre- and Post-tests

Pre-test

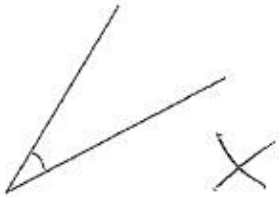
Angles 1

1. Name the parts of an angle. /3

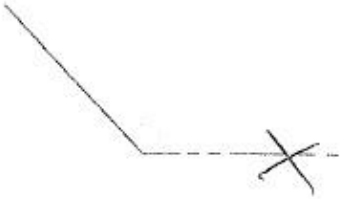
2. Name the type of angle.



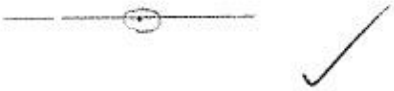
a. right



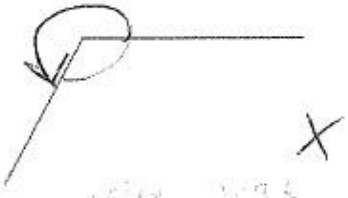
b. obtuse



c. acute



d. straight

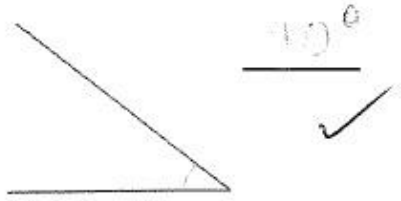


e. reflex

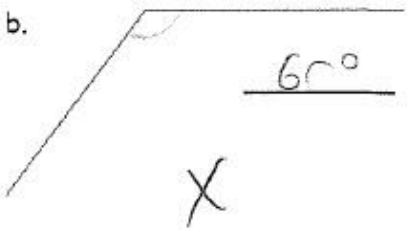
2/5

3. Measure the angle using a protractor.

a.



b.



/2

4. Explain how a protractor is used to measure angles. /2

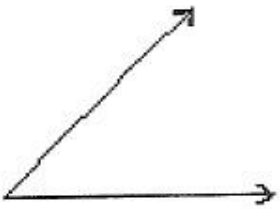
5. Construct the following angles using a protractor. /2

a. 75°

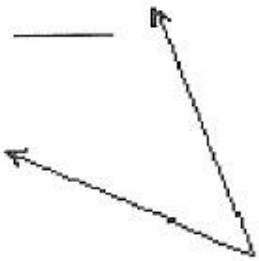
b. 130 °

5. Match the angle to the degrees. /6

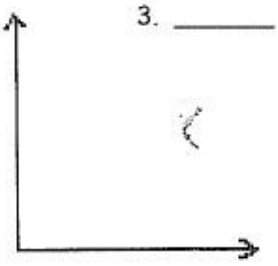
1. _____



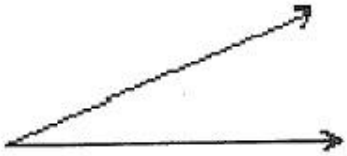
2. _____



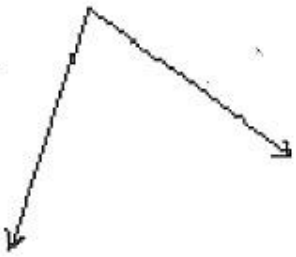
3. _____



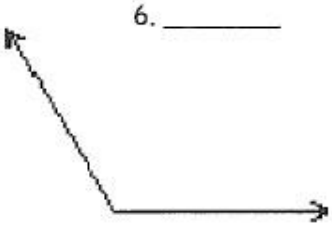
4. _____



5. _____



6. _____



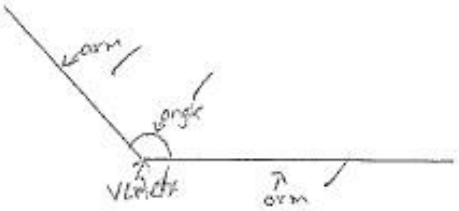
45°	72°	45°	90°	23°	120°

Total - _____/20

Post-test

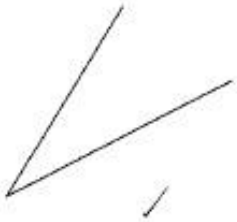
Angles 1

1. Name the parts of an angle. 3/3

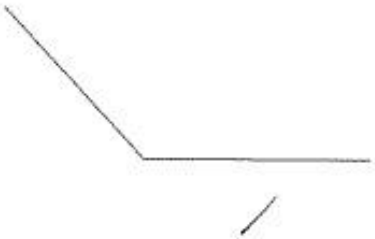


2. Name the type of angle.

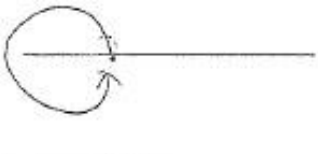
a. right angle



b. acute angle



c. obtuse angle

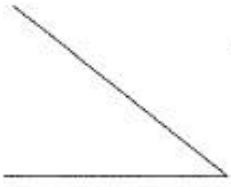


d. revolution

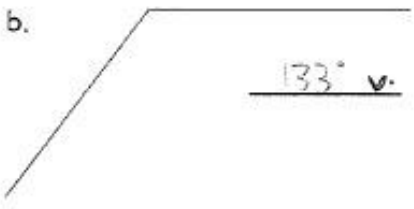
e. reflex angle

5/5

3. Measure the angle using a protractor.

a. 

41°

b. 

133° ✓

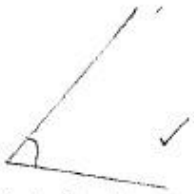
90% 1/2

4. Explain how a protractor is used to measure angles. 1/2

You put the middle of the protractor on the vertex of the angle.

5. Construct the following angles using a protractor. 2/2

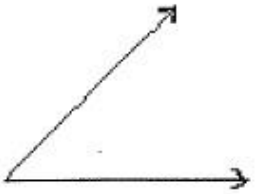
a. 60°



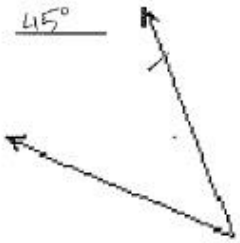
b. 175°

5. Match the angle to the degrees. 6/6

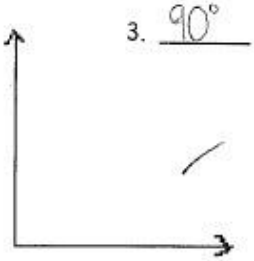
1. 45°



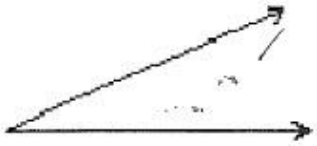
2. 45°



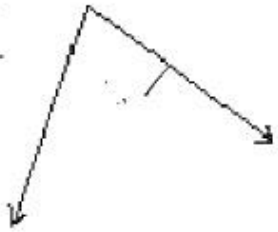
3. 90°



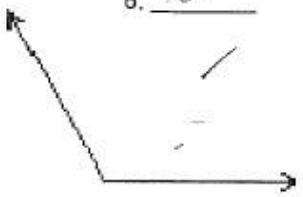
4. 23°



5. 72°



6. 120°



45°	72°	45°	90°	23°	120°

6. What are vertically opposite angles? Vertically opposite angles are equal ✓

Appendix 17: School H Unit of Work

Number and Algebra –Fractions and Decimals:

Stage 3 – Year 6: Term 2 and 3 – 2016:

Number and Algebra	Duration
Substrand: Fractions	Term 2 Week 10 – Term 3 Weeks 1, 3, 4 & 5.

Outcomes	Key Ideas	Overview
Outcomes MA3-1WM describes and represents mathematical situations in a variety of ways using mathematical terminology and some conventions MA3-2WM selects and applies appropriate problem-solving strategies, including the use of digital technologies, in undertaking investigations MA3-3WM gives a valid reason for supporting one possible solution over another. MA3-7NA compares, orders and calculates with fractions, decimals and percentages	*Key Ideas* Place fractions with denominators of 2, 3,4,5,6,8,10 and 12 on a number line between 0 and 1. Compare and order unit fractions with denominators of 2,3,4,5,6,8,10,12 and 100. compare the relative value of unit fractions by placing them on a number line between 0 and 1 (Communicating, Reasoning) investigate and explain the relationship between the value of a unit fraction and	*This unit of work encompasses:* *Assumed Knowledge* Able to define a fraction. Communicate to teacher and peers. *Links to learning across the curriculum* • Students' literacy skills are developed as they describe the properties of three dimensional shapes and associated terminology. *Language* Fraction, part, whole, numerator, denominator, number line.

	its denominator (Communicating, Reasoning)	

Teaching, learning and assessment	Teaching, learning and assessment	Teaching, learning and assessment
Stage 3 – Fractions **Introduction:** Define fractions- discuss as a class. Students to write definition in Maths book. Discuss terms such as denominator and numerator. **Activity 1:** Group 1 – on floor Define Fraction. Discuss that a fraction is part of a whole. Examples do on mini white boards. Explain how 4/4 is the same as 1 whole, etc. Discuss Number lines and placing fractions on number line. Using masking tape make a number line from 0 to 1. Using post it notes have students discuss where ½ would be placed. Complete more examples as a group 1/3, 2/3/3/3, 1/4, 2/4, 3/4, 4/4. Complete worksheet on writing simple fractions on number line.	**Stage 3 – Fractions** **Activity 1:** Group 2 Discuss fractions on a number line which have different denominators. Define denominator and numerator. Why do we need to make the denominator the same for fractions if we are to order them or place them on a number line? Show powerpoint on how to change fractions so that they have the same denominator. Do examples with class. Complete Worksheet on ordering fractions. Practise concepts on the website/App Matific	**Stage 3 – Fractions** **Activity 1:** Group 3: Complete worksheet on ordering fractions. Mark Work – discuss any difficulties. Practise concepts on the website/App Matific.

Practise concepts on the website/App Matific.		
Activity 2: Group 1 – on floor Discuss how to order fractions on a number line when the denominators are different. Show powerpoint. Use mini white boards to do examples. Discuss how we need to think does this make sense. Is 2/5 going to be placed near 1 on a number line? Complete worksheet with partner. Comparing Fractions Worksheet. When completed correct with group, check with difficulties in understanding. Practise concepts on the website/App Matific. **Introduction:** Discuss how to use strategies to add fractions with the same denominator. Do examples on smartboard using diagrams. Class to do examples. Discuss the term proper fraction.	**Activity 2:** Group 2: Comparing fractions - Ordering fractions to find which is greater or less. Discuss the signs for greater and less than. Do examples on smartboard. Worksheet to be completed. Practise concepts on the website/App Matific. **Key Ideas** Investigate strategies to solve problems involving addition and subtraction of fractions with the same denominator (ACMNA103) Model and represent strategies, including using diagrams, to add proper fractions with the same denominator,	**Activity 2:** Group 3: Ordering fractions to find which is greater or less. Discuss the signs for greater and less than. Do examples on smartboard. Worksheet to be completed. Practise concepts on the website/App Matific.

Practise concepts on the website/App Matific.		
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Discuss how to use strategies to add proper fractions with different denominators. Do examples with class. **Activity 3:** Group 1 – on floor Adding and subtracting fractions together with the same denominator. Examples to be done as a group using mini whiteboards. Then adding and subtracting with different denominators.	where the result may be a mixed numeral. Model and represent a whole number added to a proper fraction with the same denominator. Model and represent strategies, including using diagrams, to add mixed numerals with the same denominator. Use diagrams, and mental and written strategies, to subtract a unit fraction from a whole number including 1. Solve word problems that involve addition and subtraction of fraction with the same denominator. Use estimation to verify that an answer is reasonable (Problem Solving, Reasoning). **Activity 3:** Group 2: Adding and subtracting fractions with different denominators. To complete worksheets. Discuss any difficulties Practise concepts on the website/App Matific.	**Activity 3:** Group 3: Adding and subtracting fractions with different denominators. To complete worksheets. Discuss any difficulties. Review and explicit teaching on adding and subtracting fractions with mixed numerals with unlike denominators. Practise concepts on the website/App Matific.

Activity 4: **Group 1:** Discuss improper fractions and mixed fractions. Use mini whiteboards to do examples. Practise concepts on the website/App Matific. **Introduction:** Equivalent fractions Use manipulatives to find equivalent fractions. Write these in Maths book. Introduce fraction wall – discuss how fractions can be equivalent. Define equivalent fractions. Use mini white boards to do quiz- students use fraction wall to find answer or manipulatives. Students to make observations and look for patterns. Practice writing equivalent fractions as a group.	Write fractions in their 'simplest form' by dividing the numerator and the denominator by a common factor. Recognise that a fraction in its simplest form represents the same value as the original fraction (Reasoning). **Activity 4:** **Group 2:** Complete worksheet. Practise concepts on the website/App Matific. **Key Ideas** **Equivalent Fractions:** Find equivalent fractions using diagrams and numerals. Develop mental strategies for generating equivalent fractions, such as multiplying or dividing the numerator and the denominator by the same number. **Activity 5:** Students complete worksheet on equivalent fractions. Discuss. Practise concepts on the website/App Matific	**Activity 4:** **Group 3:** Complete worksheet. Practise concepts on the website/App Matific. **Activity 5:** **Group 3:** Students complete worksheet on equivalent fractions. Discuss. Practise concepts on the website/App Matific

Activity 5: **Group 1:** Students find equivalent fractions using concrete materials in pairs. Use a mini white board and cut up equivalent fractions they explore how to make fractions that are equal to one another. Write these finding in their maths book. Write equivalent fractions for the following – using different textas 2/6, 5/12, 1/8 etc. Make observations and look for patterns. Practise concepts on the website/App Matific		

Appendix 18: School H Pre- & Post Test

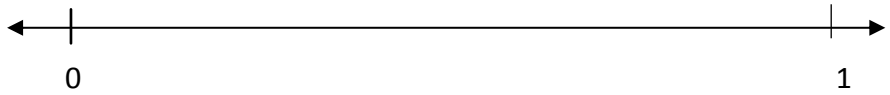
/25

Name: _____

Fractions

Ordering Fractions

1. Place the following fractions on the number line below $\frac{1}{2}, \frac{3}{5}, \frac{1}{10}, \frac{7}{10}, \frac{2}{5}$



/5

Equivalent Fractions

2. Write this fraction in its simplest form and explain how you worked it out.

a) $\frac{6}{8}$

_____

_____

/2

Write an equivalent fraction for this fractions.

/2

b) $\frac{5}{6}$ = _____

Mixed Numerals

3. Write this fractions as a mixed numerals and explain how you worked it out.

$\frac{13}{3}$ =

_____

_____

/2

Improper Fractions

4.

a) Write this mixed numeral as an improper fraction.

$3\ \frac{5}{8}$ = _____

b) Draw a diagram to represent this mixed numeral.

c) Convert this mixed numeral to an improper fraction. Explain your chosen strategy. /3

_____

_____

_____

_____

Adding and Subtracting Fractions

5. Complete the following:

a) $\frac{2}{3} + \frac{1}{6} =$ _____ Explain your chosen strategy. _____ _____ _____ /2	b) $4\frac{3}{5} + \frac{4}{5} =$ _____ Draw a diagram to show how you worked it out. /2
c) $\frac{9}{10} - \frac{1}{5} =$ _____ Explain your chosen strategy. _____ _____ _____ _____ _____ /2	d) $1\frac{2}{3} - \frac{1}{3} =$ _____ Draw a diagram to show how you worked it out. /2

Problem Solving

6. For the following question show your working and explain your chosen strategy.

a) Three people bought 24 lollies. One person ate $\frac{1}{8}$, the next person ate $\frac{3}{8}$. How many lollies were left for the third person?

/3