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An investigation into teachers' reflections on noticing as a key action of informal classroom mathematics assessment

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Abstract

Noticing what students say and do is a natural, everyday act for a teacher. An important part of teaching involves observing the classroom, choosing what to notice, and making sense of moments that are pedagogically relevant. The classroom is a complex environment where teachers are required to notice and act for many learners simultaneously. Identifying moments that are meaningful to students' mathematics learning, particularly those moments that reveal students' mathematical thinking, is an important skill. In an era of data education and increased accountability for schools, it is essential to make the practice of teacher noticing a more visible practice.

In recent years there has been increased interest in research focused on teacher noticing. This study was informed by two frameworks for noticing: the *Learning to Notice* framework (Van Es & Sherin, 2002) and the *Professional Noticing of Children's Mathematical Thinking* (Jacobs et al., 2010). In this study, what focuses primary teachers' attention to notice moments meaningful to mathematical learning and how they respond to what they notice will be explored, building on existing research. Conducted during the COVID-19 pandemic in 2020, the timing of this study provided the opportunity to compare the practice of noticing between two different contexts, the online learning environment during Emergence Remote Teaching (ERT) and the face-to-face classroom after ERT. The aim was to investigate teachers' reflections on noticing as a key action of informal formative classroom mathematics assessment from the teacher's perspective.

A general qualitative research method was adopted for this study grounded in an interpretivist epistemological view. Eight teachers from seven different primary schools, teaching Years 3 to 6, participated in the study. Due to the COVID-19 pandemic, lesson observations were not possible as researchers were unable to obtain permission to enter schools for data collection. Consequently, two semi-structured interviews were conducted online with each participant on two separate occasions: first during online learning and then after returning to face-to-face teaching. Thematic analysis was used to identify themes and patterns within the data in relation to the research questions (Braun & Clarke, 2013).

Findings revealed that teachers' interactions with students strongly influenced what they noticed and how they responded. Through observing students' dispositions, attitudes, and learning approaches during online instruction, teachers gained a deeper understanding of each student as an individual learner of mathematics. This richer perspective enabled teachers to focus not only on what students learn but also on how they learn across both online and face-to-face settings.

During ERT, limited interaction opportunities reduced teachers' chances to notice and respond in real time. The absence of spontaneous, in-the-moment noticing and responding, along with missed incidental teaching and learning opportunities, underscored the value of these everyday practices in the classroom. These powerful observational assessments provide teachers with immediate information that can enhance students' learning in mathematics, reaffirming the importance of such informal formative assessment practices for effective, responsive teaching in mathematics.

Additional insights were revealed, including the importance of the learning environment. With greater knowledge of their students and a deeper understanding of their students as learners of mathematics, teachers were able to create learning environments that best met their students' needs. They reported implementing strategies to structure the learning environment to maximise engagement in mathematics lessons, empower students to take ownership of their learning, and facilitate rich discussions and interactions.

By effectively using teacher noticing as a form of informal formative assessment in the mathematics classroom, teachers can be more responsive to meeting the needs of all their learners. Understanding the interplay between teacher-student relationships, the learning environment, and teacher noticing can enhance the effectiveness of informal formative assessment and provide richer insights into student learning.

Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature:

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Chapter 1: Introduction

This thesis commenced during a period when education was becoming ever increasingly data driven, particularly mathematics education. The aim was to highlight teacher noticing as an effective informal formative assessment practice. Through these observations, teachers can gather real-time evidence of student learning, facilitating immediate feedback and make adjustments to learning and thinking in the moment. This form of assessment can be seamlessly integrated into daily lessons, enabling teachers to gain deeper insights into what students know and can do in mathematics. Underpinning this research were two noticing frameworks, Jacobs et al.'s (2010) *Professional Noticing of Children's Mathematical Thinking* framework and Van Es and Sherin's (2021) *Learning to Notice* framework.

In this introductory chapter, an overview of this study is provided highlighting the importance of teacher noticing. Firstly, background information is provided, including motivation for the study. The context of the study is then outlined. In the next section, the aims of the study, the research questions are presented. Finally, an overview of the thesis concludes the chapter.

To further understand the need for this study the following section includes an overview of classroom mathematics assessment and background information on the practice of teacher noticing.

1.1 Background

1.1.1 *Classroom Assessment*

"Nobody ever got taller by being measured" (Cockcroft, 1982).

Cockcroft's quote captures the difference between learning and assessment. It focuses our attention on the importance of learning and the role of assessment. The nature of assessment has changed over the years. Lowrie et al. (2012) found that increased emphasis on accountability in schools has influenced the representation of assessment and the future direction it is taking.

Callingham (2010) argues that assessment is the most powerful element in teaching and learning. In education, the term *assessment* refers to the wide variety of methods or tools that educators use to evaluate, measure, and document the academic readiness, learning progress, skill acquisition, or educational needs of students**.** As outlined by the

Department of Education and Training Victoria, a variety of assessment practices should be employed for three primary objectives: assessment for learning, assessment as learning, and assessment of learning (Victora State Government. Department of Education, 2024). This study will focus on assessment for learning.

When discussing assessment, formal evaluation methods such as tests and quizzes often come to mind. However, in recent years, more informal assessment practices have gained attention. Informal assessment can occur organically through classroom interactions as students are engaged in learning. While teachers are walking around the classroom, they can be observing and engaging in conversations with the students. These interactions enable teachers to gauge students understanding in the moment, make necessary adjustments and address any misconceptions immediately (Cole, 1999). The integration of assessment into instruction allows students to continue learning while the assessment is taking place, seamlessly blending assessment with instruction.

The integration of assessment into teaching and learning is the central focus of this study. Specifically, the aims were to explore what focused teachers' attention to notice meaningful moments, what insights they gain about their students' mathematical thinking from the interactions, and how they respond to these events in the classroom. Despite their significance, everyday teacher actions such as circulating and engaging in conversation with students during lessons are often underappreciated and deserve more attention (Jacobs & Empson, 2016). Callingham (2010) emphasised the importance of skilled teachers who can make rapid professional judgements in-the-moment in busy classroom environments. The evaluative judgements made in-the-moment are the critical assessments of students' mathematical thinking that are the focal point in this study.

1.1.2 *Teacher Noticing*

Teacher noticing is a critical component of informal formative assessment in mathematics classrooms. Teachers are able to observe, interpret, and respond to students' thinking and understanding in real-time during daily classroom interactions. This practice allows teachers to give immediate feedback and make adjustments to support student learning.

Teachers routinely pay close attention to events in their classrooms. Noticing what students say and do is a natural, everyday act for a teacher. However, the classroom is a complex environment and not all events are of equal significance. An important part of teaching is observing the classroom and choosing what to notice, and how to make sense of moments that are pedagogically relevant (Van Es, 2011). Teacher noticing in mathematics education has been extensively studied for decades. While numerous concepts derived from

this body of work are not groundbreaking, these strategies and techniques are still not widely practiced. Knowing of this practice, and of these eliciting techniques and strategies is one thing; figuring out how to make them work in the classroom is an entirely different challenge. Exploring how teachers enact these strategies and techniques in their classrooms was an area of investigation in this study.

Jacobs et al. (2010) focused their work on the type of in-the-moment instructional decision making where students' thinking is central. This instructional decision-making is another element of teaching that is of particular interest in the current study. Despite previous research on in-the-moment decision making around students' thinking, and the documented benefits for both students and teachers, creating instruction that builds on students' thinking has proven to be challenging (Jacobs et al., 2010). Jacobs and Empson (2016) further advocated for increased research investigating instruction centred on students' thinking, highlighting the underappreciated parts of the lesson where teachers circulate and engage in conversation with students. Their findings revealed that teachers spent one third to one half of each lesson engaged with students in this manner. Thus, Jacobs and Empson (2016) underscored the need for further research into what teachers do and say during the circulating phase and the benefits of these conversations. The primary objective of this current study was to highlight this particular classroom practice, emphasising the meaningful moments teachers notice and this powerful form of observational assessment.

1.1.3 *Motivation for the Study*

The purpose of this study was to highlight the practice of teacher noticing as an effective form of informal assessment in the primary classroom context. The aim was to find out what is involved for the teachers in noticing critical mathematical moments in the primary classroom.

In my experience, I found advancements in technology have led to the creation of mathematics programs designed to assess our students on a range of mathematical concepts. While it may be tempting to depend solely on technology to gauge our students' knowledge, it may not provide a comprehensive view (Fahlgren et al., 2021). Teachers may still find themselves missing information, for example, uncertainty about students' misconceptions and their thinking processes in mathematics.

Through my extensive experience as a Mathematics Specialist, Mathematics Mentor and Leading Teacher of Mathematics in my school, I have observed the challenges that teachers encounter with mathematics assessment. As schools face increased accountability measures (Keddie & Holloway, 2020), teachers feel compelled to assess their students'

mathematical knowledge and skills more frequently. The pressure to gather sufficient evidence of student achievement and mathematic growth can lead to a heavy reliance on data from formal assessments, undermining teachers' trust in their own judgements and anecdotal knowledge of their students.

The availability of online platforms offering pre-made assessments that are easily assignable and instantly graded appears to offer a convenient solution to assessment. However, despite having an assessment book full of scores and percentages from various assessments, teachers that I worked with often found themselves struggling to confidently gauge students' academic progress and make informed teacher judgements.

In my various roles, I encountered teachers struggling with the challenge of writing reports and making accurate teacher judgements based solely on numerical data. Even with an abundance of graded assessments covering diverse mathematical concepts, crucial information regarding students' understanding, misconceptions, and thinking process remained elusive. This is vital Information that can be gained through classroom observations and interactions, facilitated by the practice of teacher noticing.

When contemplating the impact of technology on mathematics assessment, I often draw parallels to Australian Rules Football. Today technology allows us to review plays sometimes challenging umpires' decisions, much like in many other sports. What strikes me as interesting is the growing tendency for umpires to defer decision-making to technology rather than relying on their own judgement.

This trend prompts the reflection: Have we, as educators, followed a similar path? Are we increasingly relying on the technology to assess our students and gauge where they are in their learning? Have we begun to doubt our assessment abilities believing that technology can provide more accurate assessments?

Just as in football, where technology aids decision-making but does not replace the expertise of umpires, it is essential to recognise the value of teachers' insights and judgments in assessment. While technology can enhance assessment practices, it should complement rather than overshadow teachers' expertise in understanding and evaluating students' learning (Fahlgren et al., 2021).

1.2 Context of the Study

The purpose of this study was to investigate teachers' reflections of noticing as a key action of informal formative classroom mathematics assessment. The timing of this study provided the opportunity to compare the practice of noticing between two different contexts.

Early 2020 saw the COVID-19 pandemic sweeping the globe which inevitability led to people all around the world being put into lockdown. In April 2020, Victoria entered its first of many lockdowns due to the COVID-19 pandemic. These lockdowns led to the closure of schools across the state. Schools were faced with the sudden shift from face-to-face teaching to learning online. This became known as Emergency Remote Teaching (ERT). The term ERT refers to a temporary shift in the delivery of education from the typical modes of teaching to online teaching in response to a pressing and crisis situation (Hodges et al., 2020). ERT was a unique situation for everyone involved. Teachers and students were asked to make adaptions regarding teaching and learning that many involved had not seen in their lifetime.

Victoria had two main lockdowns in 2020, totalling 154 calendar days. This meant that schools spent about half the year learning online from home. ERT allowed schools to continue providing learning to students minimising the disruption by the school closures. It has also given us another view of online learning with the potential for new opportunities and reflections for the education system.

What was unknown about ERT was how teacher practices would transfer to the online environment. The aim of this study was not to evaluate ERT itself but to examine how particular teaching practices transferred to the online environment. Given the time spent in ERT in 2020 and 2021 there is a need to know what worked well and what did not work as well. This study focuses in on one particular area, teacher noticing as a form of informal formative assessment, and teachers' reflections of adapting this teaching practice to suit the online environment.

Transitioning to ERT would not have been feasible without the internet and the advanced technology we now have at our disposal. However, for schools accustomed to only face-to-face instruction, adapting these practices to the online environment posed significant challenges, especially considering the limited time teachers had to make such adjustments.

Recent studies from various countries have discussed student engagement and the digital divide (Bissessar, 2021; Ferri et al., 2020; Kalogeropoulos et al., 2021; Khlaif et al., 2021; Potyrała et al., 2021). These studies highlighted issues such as limited access to technology, the need to share resources at home, insufficient internet connectivity, and a lack of technological skills. In response to these challenges, the Victorian government, along with individual schools, provided families with technology by loaning out laptops and tablets. Additionally, dongles were distributed to facilitate internet access, to ensure that all students could continue learning online.

Teachers and schools are to be commended for their collaborative efforts in swiftly transitioning to online learning within a short timeframe. A report published in April 2020, early in our online learning journey during the COVID-19 pandemic, stated that teachers' confidence in using technology during online learning varied (Flack et al., 2020). In my experience, I found that despite the challenges, including stress and uncertainty, many teachers demonstrated great levels of adaptability, creativity, and resilience throughout the transition period.

The act of noticing in the face-to-face classroom environment is considered a complex task (Sherin & Russ, 2011), a complexity amplified during online learning when teachers and students were physically separated. From my own observation, the lack of student engagement and interaction during online learning posed significant challenges for teachers in noticing their students' mathematical thinking.

1.3 The Study

1.3.1 *Aims*

The main aims of the study were:

1. To investigate teachers' reflections of noticing as a critical action of informal mathematics assessment from the teacher's perspective.

2. To identify what teachers' notice that is meaningful for mathematical learning in different contexts and how the information gained through these moments can be used to enhance student learning.

This study adopted a qualitative research design, using semi-structured interviews for data collection.

1.3.2 *Research Questions*

The study was structured around three key research questions:

1. What focuses primary teachers' attention to notice moments meaningful to mathematical learning?

2. How do teachers respond to what they notice?

3. Regarding mathematics learning, how does what teachers notice and respond to in the online context compare to the face-to-face context?

It is important to define the term *meaningful moments* as employed in the research question. These moments denote events that hold considerable value and significance for the teachers. They are instances that the teachers recalled and shared with the researcher during interviews, which were meaningful because they were vividly remembered and recounted to address specific inquiries.

1.4 Overview of the Thesis Structure

The thesis is organised into six chapters. This chapter, Chapter 1, included an overview of the study, provided background information and context for the study, and described the purpose, aims and the research questions.

In Chapter 2, an in-depth exploration of the literature is presented. Two noticing frameworks employed in this study are delved into, alongside an examination of social constructivism as the theoretical background to this study. Literature pertaining to assessment, teacher noticing, and online learning is addressed.

The methodology is presented in Chapter 3. This chapter includes a detailed explanation of the research design, including data collection methods and analysis, along with a discussion of the ethical considerations and steps that were taken to ensure the rigour and trustworthiness of the research.

In Chapter 4, the findings are presented. Key findings were identified under three main themes: Adaptions to mathematical instruction: Teacher responsiveness, Student participation and dispositions, and Communication with families. Quotes from the interview transcripts are included to provide excerpts of evidence from the teacher participants and illustrate specific aspects of the findings. Each main theme was reported for two contexts, the online environment (during ERT) and the face-to-face classroom (after ERT).

Chapter 5 is the discussion chapter where the findings are discussed in light of the research question, existing literature, and theories. The discussion is presented in three sections focused on each of the three research questions listed above.

Chapter 6 is the last chapter in this thesis. In this chapter, the key findings are drawn together and discussed in relation to the research questions that framed the study. It also states the implications of the findings, limitations of the study, and recommendations for future research.

Chapter 2: Literature Review

The aim of this study was to explore teacher noticing as a critical action of informal mathematics assessment from the teachers' perspective. The study sought to identify moments teachers notice that are meaningful to mathematical learning in different contexts and how the information gained through these moments can be used to enhance student learning. In this chapter, an overview of the relevant research from three key areas will be presented, offering the necessary background for this study.

In the first section of this chapter, a social constructivist view of learning, which serves as the lens for this study, is discussed. In the next section, the body of literature around formative assessment is presented, with an emphasis on classroom interactions as a form of informal formative assessment in the mathematics classroom. In the third section, the focus shifts to the practice of teacher noticing in the mathematics classroom, outlining the frameworks underpinning the study. Recent literature, particularly focused on online teaching and learning of mathematics, published since the COVID-19 pandemic began, is presented in the final section.

2.1 Teaching and Learning in the Mathematics Classroom

This study is centred around the practice of teacher noticing in the primary mathematics classroom. Mason (2003) asserted that noticing "lies at the heart of learning and teaching" (p. 281) and has the potential to make learning and teaching more effective and efficient. Sherin et al. (2011b) wrote that noticing in the mathematics classroom has the potential to develop teachers' skills in adaptive and responsive teaching, thereby enhancing their practice. While activities related to teacher noticing have been discussed for decades, recent approaches with a more constructivist focus centred on student thinking have led to a new wave of studies (Sherin et al., 2011a).

As a researcher focusing on mathematics teacher noticing, a particular stance towards teaching is assumed. This stance views the teacher as an active participant in an interactive classroom, where numerous opportunities are created to elicit students' thinking. With this perspective, a social constructivist lens was employed in the research design and data analysis to explore what teachers noticed, how they responded, and the effects on student learning. In the following sections, literature related to social constructivism and key aspects of a social constructivist classroom relevant to this study are presented.

2.1.1 *Social Constructivism*

Dewey (1916) advocated for the move from what he called a more traditional education to a more progressive one. He described the traditional classroom as one in which information and skills were passed on from teacher to student to ensure students were well prepared for their future responsibilities. Students were passive learners, and teachers were dispensers of knowledge (Dewey, 1916). In contrast, a more progressive classroom would have the teacher as a facilitator or guide where students learn from experiences instead of directly from textbooks or the teacher. In this model, teachers, and students co-construct knowledge, with the quality of these experiences profoundly effecting a students' education. Dewey (1916) stated, "Democratic social arrangements promote a better quality of human experience" (p. 25).

Constructivism is a theory of learning whereby knowledge is thought to be actively constructed rather than passively received. Faulkenberry and Faulkenberry (2006) shared their perspective on constructivism in mathematics education, highlighting the teacher's role as one of a guide. The teacher creates engaging, hands-on experiences and real-life tasks using concrete materials to facilitate mathematics learning. These methods align with the work of Kalina and Powell (2009), who noted the cognitive and social benefits of such strategies. During learning experiences, teachers assess the learning and modify as needed, becoming a partner in the learning process (Faulkenberry & Faulkenberry, 2006). Despite variations in what constructivism looks like across classrooms, one commonality is the students at the centre of the learning. Bada and Olusegun (2015) stated that this shift from traditional, teacher-led classrooms to student-centred learning could be the most important contribution of constructivism.

Social constructivism serves as the theoretical position underpinning this study, emphasising the critical role of social interactions in the learning process. Rooted in the work of Vygotsky, this perspective asserts that learners construct knowledge and develop understanding through their daily social interactions within the classroom (Kalina & Powell, 2009; Watson, 2001). Vygotsky and Cole (1978) argued that cognitive development begins on a social level through interactions with others before being internalised on an individual level. This progression highlights how learning is first facilitated socially and later processed individually to deepen understanding (Vygotsky & Cole, 1978).

Vygotsky's Sociocultural Theory posits that learning and development are deeply embedded in cultural and social contexts (Jaramillo, 1996). Central to this theory is the concept that all higher-order cognitive functions, such as reasoning, problem-solving, and critical thinking, originate in social interactions. These functions are mediated by cultural tools—most notably language—which act as both a means of communication and a

framework for thought. Language enables learners to organise their experiences, express their ideas, and internalise new knowledge, making it an essential tool for both teaching and learning (Vygotsky & Cole, 1978).

A key tenet of Vygotsky's theory is the Zone of Proximal Development (ZPD), which represents the range of tasks a learner can perform with guidance but cannot yet complete independently (Chaiklin, 2003). The ZPD emphasises the importance of scaffolded instruction, where teachers or peers provide support to help learners bridge the gap between their current level of understanding and their potential development. This scaffolding can take many forms, such as modelling, questioning, or offering prompts, and is gradually removed as learners gain independence. The ZPD highlights the dynamic nature of learning and underscores the importance of responsive teaching practices that adapt to the needs and abilities of individual students (Vygotsky & Cole, 1978).

In the context of this study, Vygotsky's work provides a powerful lens for understanding how teachers notice and respond to students' mathematical thinking. The social nature of classroom interactions enables teachers to observe students' cognitive processes, interpret their understanding, and provide tailored support to extend learning. Furthermore, the emphasis on language and discourse aligns with the informal formative assessment practices, where conversations and questioning serve as key tools for uncovering students' thought processes and guiding instructional decisions.

Kalina and Powell (2009) describe an effective classroom as one where students communicate optimally. Social interactions in the classroom have the potential to have a great effect on students' learning and how it occurs. Interactions should not only occur between teacher and student, but opportunities should also be provided for collaborative learning where students can learn from each other. Kalina and Powell (2009) stated that a social constructivist environment that is interactive and student-led can benefit both student and teacher.

Watson (2001) further characterised a social constructivist classroom as one that integrates assessment into the teaching and learning process, rather than treating it as a separate activity. This approach shifts the focus from assessment *of* learning (e.g., formal testing) to assessment *for* learning. Teachers in a social constructivist classroom utilise interactions, observations, and listening as informal assessment tools to uncover shared understandings and gain insights into students' thinking (Adams, 2006). For instance, when a student explains a concept or idea, even if it is incorrect, it provides the teacher with valuable evidence of the student's mathematical thinking. This evidence enables teachers to extend or adapt instruction to better support learning. The integration of formative

assessment practices within the social constructivist framework will be further explored below (see Section 2.2.2).

In the following section, literature focused specifically on classroom interactions will be presented. These interactions promote social and communication skills through collaboration (Bada & Olusegun, 2015), and also provides teachers with opportunities to gather evidence of learning and understanding.

2.1.1.1 Classroom Interactions. Learning is regarded as a shared social activity embedded in classroom interactions. Research on classroom interactions dates back almost a century. In recent decades, amidst profound societal change and increased classroom diversity, researchers have intensified efforts to understand and enhance classroom interactions (Solheim et al., 2018; Zhang & Cao, 2022). This pursuit has involved developing observation strategies and techniques to gain insights into these phenomena.

The NCTM Principles and Standards, established in 2000 (NCTM, 2000) envisaged a mathematics classroom with increased dialogue between teachers and students. Central to this vision are mathematical conversations where students can argue and defend their mathematical ideas, a defining feature of a quality classroom experience. In their review of recent research on classroom conversations and interactions, Walshaw and Anthony (2008) highlighted numerous benefits. They stated that by listening to others' ideas, and receiving and providing a critique, students can enhance their own knowledge and develop their mathematical identities. Teachers who create environments allowing for such conversations and interactions give students a sense of control over their learning and develop valuable student mathematical dispositions. Additionally, teachers benefit from these interactions as they get to know their students better.

Interest in research on classroom interactions has continued to grow in recent years. Effective classroom interactions are considered important in the teaching and learning of mathematics (Zhang & Cao, 2022). In their review of recent classroom interaction studies, Zhang and Cao (2022) found three main themes. The first was the connection between interactions and students' cognitive development, with evidence from these studies proving that learning from these interactions becomes stronger. The second was the integration of interactions into specific classroom activities fostering social participation, and the third was cultural perspectives, suggesting further research from a range of different contexts was needed to investigate theories and methods that can be applied across different classrooms. Zhang and Cao (2022) also recommended more research to determine the effects of classroom practices, such as teacher noticing, on the quality of classroom interactions and the connection to students' cognitive development.

The Learner's Perspective Study by Clarke (2004) delved into various classroom practices across ten lessons internationally. One particular practice, a type of classroom interaction termed *Kikan-Shido* or *between desk instruction*, involved teachers moving around the classroom, observing students' individual or group work. During this time, the teacher may or may not speak or interact with the students (Clarke, 2004). Although rooted in Japanese methods, Kikan-Shido is a familiar practice of teachers across many countries. Australian teachers utilised between desk instruction for three primary purposes: monitoring and encouraging on-task activity, actively scaffolding the learning, and monitoring the completion of tasks. Notably, the three Australian teachers in the study frequently employed this practice in every lesson, often found to be kneeling or sitting beside students, engaging in discussions related to their tasks. In contrast, among the US participants, only one teacher utilised this practice (Clarke, 2004). This study highlighted this crucial lesson event where Australian teachers provided targeted instruction and gained insights for future planning. A lack of between desk instruction during lessons posed challenges in effectively monitoring student learning. In the current study, the daily interactions that occur during mathematics lessons were a focal point, aiming to find out what focuses teachers' attention, what teachers notice, and how (or if) teachers decide to respond in these moments.

Classroom interactions were also studied by Pöysä et al. (2019), who examined students' engagement from the perspective of the student during lessons involving teacher-student interactions. Their study, based on 155 video-recorded lessons with 709 Year 7 participants from 59 classrooms, provided evidence that teacher-student interactions can foster student engagement. Findings revealed that both emotional support, provided by the teacher, and organisational support through their management of the lesson had positive effects on students' engagement during lessons.

Classroom interactions will be discussed further in relation to informal formative assessment strategies (see Section 2.2.3). Given the impact of classroom interactions on student engagement, literature concerning student engagement will be discussed in the next section.

2.1.1.2 Fostering Engagement. It seems pertinent to discuss engagement in relation to this study for two reasons: the connection between teacher-student interactions and engagement (Pianta et al., 2012; Pöysä et al., 2019), and the context of online learning (Research Question 2). Entering ERT, there was uncertainty amongst teachers about how students would respond to this new way of learning.

While research on engagement spans a broad spectrum, this study specifically targets research related to mathematics and classroom interactions. For example, Fredricks et al. (2004) emphasised the importance of school engagement, while Attard (2012) and

Skilling (2014) concentrated on engagement in the mathematics classroom. These studies also highlight factors that influence student engagement, including learning experiences, teaching approaches, and teacher-student interactions. The literature discussed in this section has been chosen for its relevance to this study.

Merriam-Webster (Merriam-Webster, n.d.) defines engagement as: “an arrangement to meet or be present at a specified time and place” and “emotional involvement or commitment” (para. 1). The multifaceted nature of engagement makes it hard to define. In education, researchers have used three types of engagement to describe what it looks like in the classroom: behavioural, emotional, and cognitive (Attard, 2012; Skilling, 2014). Behavioural engagement involves students’ active engagement in relevant tasks, emotional engagement occurs when students perceive the value of their learning, and cognitive engagement involves students developing their understanding of mathematical concepts. When students are engaged on all three levels, meaning they are cognitively challenged, are actively involved, and enjoying the mathematics, they are considered to be truly engaged (Attard, 2012). As opposed to when students appear to be engaged just because they are doing the mathematics (behaviourally engaged).

In the current study, engagement aligns with a definition from Bond (2020), “the energy and effort that students employ within their learning community, observable via any number of behavioural, cognitive or affective indicators across a continuum.” (p. 3). Engagement can be shaped by a range of influences, including relationships, learning activities and the learning environment (Bond, 2020), beliefs which align with this study. Students who are engaged and empowered in their classrooms are more likely to direct that back into their learning, leading to further engagement.

Despite the range of definitions, one common finding among many studies is that student engagement contributes to learning and academic success (Attard, 2012; Fredricks et al., 2004; Skilling, 2014). Fredricks et al. (2004) also noted that student engagement is responsive to contextual factors, meaning changes in the learning environment can impact students’ engagement, a finding supported by Pöysä et al. (2019), who found that student engagement varies from one learning situation to another.

By examining the range of practices of 31 Year 7 teachers, Skilling (2014) highlighted particular practices that were found to either promote or hinder engagement. Considering engagement as separate from mathematics teaching, not knowing how to engage students, and controlling teacher styles all negatively impacted students’ engagement. Conversely, emphasising the relevance of the mathematics, looking for practical ways to apply the mathematics, following student interests, developing personal connections with students, and autonomous teaching styles were all found to enhance student engagement (Skilling,

2014). Teachers who believe in the importance of engaging students have choices about the practices they employ that can influence student engagement.

Pianta et al. (2012) stated that the nature of the interactions between teachers and students is fundamental to understanding student engagement. They believe that by increasing the quality of these interactions, teachers can increase the level of student engagement, in turn having a positive impact on learning and development (Pianta et al., 2012). A particular link was made to students' cognitive engagement, where teachers can tap into students' deeper thinking through in-the-moment opportunities within their daily interactions.

The discussion around engagement will continue below (see Section 2.4.1) with a focus on student engagement during online learning. In this section, particular practices around the teaching and learning of mathematics, with a focus on the interactive, social nature of the classroom setting have been the focus. Finding and utilising assessment practices that align with this setting can be challenging (Serow et al., 2016). Serow et al. (2016) emphasised the transformative potential of mathematics assessment in schools at all levels and advocated for practices that allow students to demonstrate *what they do know*, consider their interests and engage them. Future research needs to consider how our mathematics learning experiences, and assessment practices are aligned to find balanced mathematics assessment approaches. This study looked to blur the lines between teaching, learning and assessment.

In the following sections key literature relevant to three central areas of this study will be explored. In section 2.2, foundational literature on assessment is explored, in section 2.3 the concept of teacher noticing is presented, and in section 2.4 there is a focus on research related to online learning, particularly studies published in response to the COVID-19 pandemic.

2.2 Assessment

Lowrie et al. (2012) noted that an increased emphasis on accountability in schools influenced the future direction of classroom assessment practices. Consequently, there has been a notable shift towards assessment practices that are more quantitative in nature. To enhance students' learning, there is a need for assessment practices that build on students' existing knowledge rather than their deficiencies. Authors of reviews of assessment practices nationally and internationally (Bennett, 2011; Black & Wiliam, 1998; Lowrie et al., 2012; Serow et al., 2016) agreed that classroom assessment experiences needed further discussion in order for assessment to change and adapt with evolving education.

Serow et al. (2016) considered whether we are actually assessing what needs to be assessed. This question was raised and considered carefully when creating the proposal for this study. In describing the relationship between teaching, learning and assessment, Wiliam (2013) stated, “Our students do not learn what we teach. It is this simple and profound reality that means that assessment is perhaps the central process in effective instruction” (p. 15). Despite meticulous planning and delivery of the learning, we cannot guarantee that all our students will attain the desired learning outcomes. Hence, assessment serves as the bridge between teaching and learning (Wiliam, 2013). Only through assessment can we ascertain whether the lessons planned and implemented to engage students in mathematics resulted in the intended learning.

According to the National Council of Teachers of Mathematics (Leinwand, 2014), the primary purpose of assessment is to inform and improve the teaching and learning of mathematics. In Australia, the Australian Curriculum Assessment and Reporting Authority (ACARA, 2024) describes the curriculum and oversees the development and implementation of our national assessment NAPLAN (National Assessment Program—Literacy and Numeracy). Additionally, in Victoria, the Victorian Curriculum and Assessment Authority (VCAA, n.d.) provides access to a range of formative and summative assessments. Formative assessment, as stated by the VCAA is “any assessment that is used to improve teaching and learning” (para. 1). This study specifically centred on formative assessment practices of primary mathematics teachers.

2.2.1 *Formative Assessment*

Black et al. (2004) stated that the primary objective of any assessment is to promote students' learning. Extensive literature exists on assessment and the different roles assessment serves in education. The two main types of assessment are *formative* and *summative*. These terms apply not only to the types of assessment but the purposes they serve. Bloom et al. (1971) defined summative assessment as “tests given at the end of episodes of teaching for the purpose of grading or certifying students” (as cited in Black & Wiliam, 2003, p. 623). The main goals of summative assessment are to provide accountability, rank students, or to determine a level of competence. The results effectively summarise students’ knowledge at the time of assessment.

Although summative or formal assessment practices provide evidence of student learning suitable for reporting purposes, the timing of this information is often too late to be actionable. Lowrie et al. (2012) found the notion of assessment for learning revolutionised the way assessment was being conducted in the classroom. For teachers, this required a shift in viewing assessment as something that is completed at the end of a unit, to viewing assessment as part of daily classroom practice to be used to enhance learning. Leahy et al.

(2005) agreed, stating that assessment for learning involves adjusting teaching while the learning is still taking place, creating a shift of attention from teaching to learning. Assessment for learning is describe by Victorian Curriculum and Assessment Authority (n.d.) as “when teachers use inferences about student progress to inform their teaching” (para. 2).

The term formative assessment can be interpreted in different ways. Thompson et al. (2018) stated assessment can be considered formative if the data are used to inform further instruction rather than to evaluate for example, a mid-unit quiz where the results inform future planning. Additionally, researchers such as Wiliam et al. (2004) and Baird et al. (2017) use the terms *formative assessment* and *assessment for learning* interchangeably to describe specific daily classroom assessment practices. In this study, the term formative assessment will be used.

Researchers such as McIntosh (1997) and Thompson et al. (2018) remind us that formative assessment should not be considered an add-on to the curriculum but rather a daily practice blended into teaching and learning. Thompson et al. (2018) found that embedding formative assessment into classroom instruction helps teachers to view assessment as a social practice naturally integrated into the everyday classroom environment. According to Jacobs and Empson (2016), teachers spent up to half of each mathematics lesson circulating and engaging in conversation with students, providing opportunities to elicit students’ thinking and gather evidence which could be used as formative assessment to enhance learning.

Formative assessment information gathered by teachers in classrooms in-the-moment can be used to adapt instruction immediately, if required. Leahy et al. (2005) found that teachers employing formative assessment were looking for ways they could generate evidence of student learning to tailor the learning to meet students’ needs. By interacting with students and listening to their responses, teachers could be more responsive and use evidence to make decisions in real-time. In these moments, teachers can make instructional decisions that they otherwise may not have been able to do (Leahy et al., 2005). While teachers plan their mathematics lessons in advance, daily classroom formative assessment enables them to be flexible and to adjust the lesson direction if necessary.

Black and Wiliam (2010) found that the use of formative assessment practices can lead to significant learning gains, reporting that students taught by teachers implementing such practices achieved in six or seven months what would otherwise have taken a year. However, Callingham et al. (2009) found that teachers still face challenges in implementing these practices due to external pressures such as reporting procedures and high stakes testing.

Interestingly, Black and Wiliam (2018) and James (2006) found that most theories of learning do not discuss particular assessment strategies. This may be because they are more focused on the learning and the pedagogy, or because of the challenge of finding assessment practices that align with a particular theory of learning. The present study centres on a specific type of formative assessment referred to as *informal formative assessment* (Ruiz-Primo, 2011; Sezen-Barrie & Kelly, 2017; Wolf, 1993), sometimes referred to as *classroom assessment* (Goos, 2020; Serow et al., 2016), which aligns well with a social constructivist classroom (Goos, 2020). This form of assessment will be discussed in the next section.

2.2.2 *Informal Formative Assessment*

"In a classroom that uses assessment to support learning, the divide between instruction and assessment blurs" (Leahy et al., 2005, p. 19). This approach, known as *informal formative assessment* (Ruiz-Primo, 2011) or *classroom assessment* (Goos, 2020), emphasises that what teachers and students do in their classrooms can be considered opportunities for teachers to collect evidence of student understanding. This differs from formal formative assessment practices that are planned assessments that can be embedded into the curriculum (Ayala et al., 2008). The term informal does not necessarily mean a focus on the naturally unpredictable events that arise in any classroom, but rather the frequent opportunities teachers have for collecting information about their students' progress during lessons. These opportunities include, deskside conferences and observations (Wolf, 1993), collaborative group work, and asking and answering questions (Leahy et al., 2005), and general teacher-student or student-student conversation (Ruiz-Primo, 2011). These classroom interactions will be discussed further in the next section. According to Leahy et al. (2005), even a student sitting and looking confused provides valuable information about their level of understanding. It is important to note that these informal formative assessment practices are embedded within classroom instruction, occurring in real-time, and integrated into the lesson itself rather than being conducted afterwards or as a separate activity.

Teachers' informal formative assessments of their students have often been dismissed by those outside the classroom, and at times, even by the teachers themselves, as untrustworthy (Wolf, 1993). Nevertheless, Wolf (1993) maintains that the most valuable and valid information comes from the teachers who work closely with students on a daily basis, rather than a one-off snapshot of student performance. High quality assessment practices place students at the centre (Lowrie et al., 2012). Implementing informal assessments or classroom assessments such as those listed above not only place the student at the centre but also fosters shared responsibility for learning between teacher and student (Leahy et al., 2005)

Previous studies have examined specific types of classroom-based assessment, focusing on assessing students mathematical understanding. For example, Cheeseman and McDonough (2019) implemented an open-ended “Impress me” task with young children as an assessment tool to reveal students’ understanding of mass and weight, and Hargreaves (2013) investigated how students’ respond to the feedback teachers provide during classroom interactions. The current study focuses on general classroom interactions from the teacher's perspective, investigating teacher noticing as a critical action of informal formative mathematics assessment. The aim was to explore how the information gained through moments noticed can be used by teachers to enhance student learning.

2.2.3 *Classroom Interactions as Informal Formative Assessment*

Classroom interactions, as discussed previously, can be an effective way for teachers to effectively monitor student learning, making them a useful informal formative assessment strategy.

According to Goos (2020), viewing the process of learning mathematics as constructing knowledge in a social context, helps teachers understand how students’ learn mathematics. This perspective necessitates classroom assessment practices that make students’ thinking visible. Since teachers do not have direct access to students’ thinking, they rely on interpretating observations of classroom events. McIntosh (1997) similarly noted that teachers must be creative in finding ways to elicit students’ thinking because they cannot get into their students’ heads. One effective method is through conversations during daily classroom interactions.

Any student-student or student-teacher interaction observed in a classroom setting can be viewed as an opportunity for informal assessment. Observing students at work, asking them questions, and actively listening to their responses are inherent aspects of teaching (Vincent & Wilson, 1996). It is noteworthy, that the work of Vincent and Wilson (1996) revealed observations of students working in pairs or groups to be particularly insightful, offering genuine glimpses into students’ thought processes. They found that such observations were more conducive to developing problem solving, enhancing communication skills, and fostering critical thinking, as opposed to assessing isolated skills or algorithmic procedures. Subsequently, teachers can use information gained through these classroom observations to adjust and tailor instruction, effectively monitoring and supporting students’ learning (Vincent & Wilson, 1996).

When considering daily classroom interactions, Storeygard et al. (2010) observed that practices such as listening to students, circulating as students work collaboratively, questioning, and one-on-one conversations are integral to informal formative assessment.

They use the term *dynamic* to describe the classroom interactions used for assessment, where teachers can capture where a student is in that moment, including where the student has been and where to next. Wiliam (2013) adds that teachers should also consider the best next steps in the assessment process, or how to get there.

Ruiz-Primo (2011) believe that conversation or dialogic interactions or exchanges are at the heart of informal formative assessment. These informal assessment conversations make students' thinking explicit. Through questioning and conversations student thinking can be examined, challenged, and shaped. Importantly, the teacher does not always need to initiate these interactions; valuable information about student understanding can be obtained through observation of these interactions at any given point in time. Ruiz-Primo (2011) noted that "attention to informal formative assessment practices may help teacher education programs, school districts, and state education departments to focus on formative assessment from different angles rather than focusing only on benchmark/on-demand/ interim assessments" (p. 15). This insight serves as the cornerstone of the present study.

Informal formative assessment was a term used by Sezen-Barrie and Kelly (2017), to describe conversations between teachers and students that occur during lessons where teachers can collect evidence of learning. Informal formative assessments are designed to check student understanding and enhance learning. Sezen-Barrie and Kelly (2017) conducted observations and video recorded lessons in four science classrooms across five phases of their study. An in-depth analysis was conducted of these in-the-moment interactions and examined what teachers noticed about their decision-making processes during these interactions.

Findings stated,

> It is through IFA [informal formative assessment] that teachers, during their daily conversations with students, can identify the sources of students' ideas, evaluate students' engagement in scientific reasoning, determine the depth and breadth of knowledge they plan to teach, and help students to communicate the inferences during scientific observations and investigations. (Sezen-Barrie & Kelly, 2017, p. 206).

Kazemi et al. (2016) also viewed classroom interactions as an informal formative assessment approach that teachers can use in-the-moment in their classroom day-to-day to gain greater insight into their students' mathematical thinking, thereby aiding their instructional decisions. By actively engaging with their students, listening carefully to student contributions, and acknowledging their ideas and experiences, teachers can learn more about their mathematical thinking and understandings. Kazemi et al. (2016) emphasised that

this assessment practice enables teachers to better understand their students as mathematicians, concluding: “In a time when high stakes tests determine who is making it in our current systems, we need to make stronger efforts to hear our students and to give them voice” (p. 189).

Certain conditions were outlined by Ruiz-Primo (2011) for classroom conversations to be an effective informal assessment practice. Teachers should ensure conversations are guided by learning goals, which would provide a balance between challenging and supporting the students. Conversations should be interactive, valuing students’ responses as important contributions, and should immerse students in the subject matter. Additionally, they should be conducted in an environment that promotes higher order thinking skills and encourages knowledge construction through reasoning (Ruiz-Primo, 2011). Under the right conditions, classroom conversations become valuable assessment opportunities that provide evidence of student learning.

Ruiz-Primo (2011) highlights classroom conversations as valuable tools for fostering social participation, which can, in turn, enhance engagement. The questions posed by either students or teachers can offer insights into the type of engagement students are experiencing. For instance, a response indicating that a student is attentive but not deeply invested in the discussion’s content reflects procedural engagement (Ruiz-Primo, 2011).

Studies like these, help provide us with different perspectives on informal formative assessments. Viewing assessment as an ongoing process allows us to rethink how we understand and respond to students′ ideas in-the-moment.

Research on elements of classroom conversations have often employed the IRE (initiation-response-evaluation) sequence, looking for particular patterns in dialogue, as seen in studies by Levenberg (2014) and Cazden (2001). However, Harrison et al. (2018) argued that the IRE sequences was not a useful tool for considering classroom conversations as an effective informal formative assessment practice because it focused more on evaluative feedback rather than gathering information to make informed decisions about next steps and actions.

Classroom assessment involves eliciting evidence of student learning, interpreting that evidence and then deciding how to act. These three phases have been used in studies focused on classroom conversations as an assessment practice. For example, Pai (2018) investigated observations and conversations as an informal assessment practice in secondary mathematics classrooms in which he interviewed three teachers and documented his own experiences with using classroom conversations as a form of informal assessment.

Through his work, he hoped to help teachers expand their awareness of possibilities in-the-moment and find different ways to reflect on their classroom practices.

Eliciting is discussed as how teachers engage students, design tasks, and facilitate conversations between students. Interpreting is when the teacher attempts to make sense of what they observed and considers the students' understanding. Acting refers to what the teacher does after eliciting and interpreting information gained from their observations (Pai, 2018). Goos (2020) also referred to these phases when discussing classroom assessment practices employed in mathematics classrooms implementing a socio-constructivist approach.

These three phases are similar to skills discussed by researchers in frameworks for noticing. For example, in Van Es and Sherin's (2021) *Learning to Notice* framework, the term *shaping* is used to describe what teachers do to create more opportunities for noticing aligning with the eliciting phase. The interpreting phase is described similarly in the noticing framework and the assessment cycle and involves teachers making sense of what they notice. Deciding how to respond is a key skill in Jacobs et al.'s (2010) *Professional Noticing of Children's Mathematical Thinking* framework where teachers use their understandings to decide how best to respond. This aligns with the acting phase and highlights the importance of responding effectively after the initial phases.

Researchers such as Jacobs et al. (2010) and Van Es and Sherin (2021) have underscored the importance of noticing and assessing students' thinking in-the-moment. Both Jacobs et al.'s (2010) and Van Es and Sherin's (2002) frameworks for noticing guided this study and will be discussed further in the section following dedicated to teacher noticing.

Wiliam (2013) found that when it comes to assessment, researchers cannot tell teachers what to do, as classrooms are complex environments where different courses of action may be required in different contexts. However, research has highlighted classroom assessment as an avenue worth exploring. Regardless of the context, focusing on what the students are getting out of instruction rather than what the teacher is putting in can increase student engagement and achievement. Wiliam (2013) concludes by stating, "As long as teachers continue to investigate that extraordinarily complex relationship between 'What did I do as a teacher?' and 'What did my students learn?' good things are likely to happen" (p. 20).

When considering formative assessment practices, the focus is most often on the teachers' actions. Coffey et al. (2011) argued that the core of formative assessment lies not in what teachers do, but what they see. Teachers' awareness and understanding of the students' comprehension are vital, and it is important to consider this awareness from a

disciplinary perspective. While numerous studies have explored the relationship between noticing and formative assessment in the science discipline (Ruiz-Primo & Furtak, 2007; Talanquer et al., 2013), research in the mathematics discipline remains limited.

As this study centres around the use of teacher noticing as an informal formative assessment practice, literature on teacher noticing will be presented in the next section.

2.3 Teacher Noticing

We notice, observe, and make sense of the world around us every day. According to the Cambridge dictionary the word notice means “to see or become conscious of something or someone”. Goodwin (2015) introduced the term *professional vision* to explain how various professions view context specific situations differently. Our knowledge and experiences shape how we perceive and interpret events in our workplace. By examining how different professions develop their vision, Goodwin (2015) highlighted the importance of learning, expertise, and communication in professional settings.

Researchers such as Sherin et al. (2008) and Ho and Tan (2013) have examined teachers’ noticing utilising Goodwin’s work and the term *professional vision*. Teachers’ professional vision pertains to the perception and interpretation of classroom interactions. According to Sherin et al. (2008), studying teachers’ professional vision presents several challenges. The professional vision occurs amid the dynamic and fast-paced environment of the classroom during instruction, making it difficult to capture accurately. It is impractical to pause these moments to question the teacher about specific events they noticed. To address this, Sherin et al. (2008) equipped teachers with small, wearable video cameras to capture professional vision in action. Teachers could then later review and reflect on the moments they attended to.

Several studies (Han et al., 2023; Sherin & Van Es, 2005; Star & Strickland, 2008) have explored the use of video clubs and video-based programs as forms of teacher professional development aimed at enhancing teachers’ noticing skills. These programs used video to capture rich classroom interactions, which teachers can subsequently watch and discuss over a set period of time. This innovative use of technology effectively captured specific classroom events. However, the current study was not able to include classroom observations, and therefore the use of such technology was not feasible.

In a study by Ho and Tan (2013), the development of professional vision in the mathematics classroom was examined from both the teacher’s and the researcher’s perspectives. The researcher recorded a series of lessons, which were later reviewed by both parties. During this process, notable differences emerged in how their professional

vision developed, highlighting the different lenses through which they reflected on events. The researcher aimed to understand and interpret events to gain insights into the teacher's practice while the teacher concentrated on their own teaching practice to inform future pedagogical decisions and actions. Ho and Tan (2013) concluded that what the teacher and researcher noticed was equally as important as how they analysed these observations.

Jacobs et al. (2010) found that researchers defined noticing in a multitude of ways, but the connecting thread is making sense of how individuals process complex situations. In the dynamic and busy environment of mathematics classrooms, teachers are tasked with attending to numerous factors simultaneously. They must discern their students' interests, gauge their engagement levels, assess their understanding of tasks, delve into their thought processes, and understand the significance of these observations (Jacobs et al., 2010). Achieving this amidst the rapid pace and many distractions of a classroom is demanding, especially when considering the unique needs of each learner. There remains much to uncover regarding the practice of teacher noticing, emphasising the necessity of elevating its visibility within the teaching profession.

In a survey paper by Dindyal et al. (2021) exploring literature on teacher noticing, it was noted that the contexts in which teacher noticing is studied are expanding. Context is broadly defined to include the various factors within a classroom environment that influence teaching mathematics and teacher noticing. The current study aimed to compare what teachers notice and how they respond in two different contexts: the online learning environment during ERT and the face-to-face classroom after ERT.

Teacher noticing is a specialised type of noticing that plays a pivotal role in classroom dynamics, enhancing teacher-student and student-student interactions. The research on teacher noticing is quite diverse. In a systematic review of the literature on teacher noticing spanning two decades, König et al. (2022) found that while there was a substantial body of work on mathematics teacher noticing, most studies originate from Europe and North America. Analysis of 182 articles revealed that 71 articles focused on developing teacher noticing, with 35 of these employing digital technology in their research design. Additionally, 17 studies included both in-service and pre-service teachers, examining differences between noticing and the relationship to levels of expertise.

In this study, teacher noticing is defined as a key action of informal classroom assessment, encompassing a teacher's ability to observe, interpret, and respond to students' mathematical thinking and behaviours during instruction. This process, which takes place in the dynamic and fast-paced environment of the classroom, involves teachers engaging with students to understand and interpret events, gaining valuable insights into their learning. Teacher noticing plays a critical role in identifying meaningful moments that offer deeper

understanding into students' mathematical reasoning, enabling teachers to tailor instruction to their individual needs. Attending, interpreting, and responding are central components of teacher noticing, highlighting its importance in shaping day-to-day classroom interactions and enhancing learning outcomes. These three components will be discussed below (see Sections 2.3.1 and 2.3.2).

Wei et al. (2023) conducted a bibliometric review that systematically compared current research on teacher noticing. In their analysis of 139 articles, they found results similar to those of König et al. (2022), noting mathematics was the primary subject studied in relation to teacher noticing, with United States leading this research field. Video technology emerged as the primary tool used in these studies. While findings from United States based research have been invaluable, this study contributes to the literature by providing an Australian perspective focused on primary school settings. Wei et al. (2023) also highlighted the usefulness of frameworks in studying teacher noticing, identifying Van Es and Sherin's (2002) *Learning to Notice* and Jacobs et al.'s (2010) *Professional Noticing of Children's Mathematical Thinking* as the two most widely used frameworks. These are the frameworks that guided this study.

Van Es and Sherin (2002) propose three key aspects to noticing in their *Learning to Notice* framework:

> (a) identify what is important or noteworthy about a classroom situation, (b) making connections between the specific classroom interactions and the broader principles of teaching and learning they represent and (c) using what one knows about the context to reason about classroom interactions (p. 573)

Similarly, Jacobs et al. (2010) describe similar skills involved in teacher noticing in their construct focused on professional noticing of students' mathematical thinking: (a) attending to children's strategies, (b) interpreting children's understandings, and (c) deciding how to respond on the basis of children's understandings (p. 169).

These two frameworks were used in the design of this research project. The specific components from these noticing frameworks attending, interpreting, and responding will be discussed in more detail in the next section.

2.3.1 *Attending and Interpreting*

Researchers such as Amador et al. (2017) and Sherin and Star (2011) found that when asking teachers about their classroom interactions, it was often difficult to distinguish between what they identified as noteworthy events and their interpretations of those events.

The complex relationship that exists between noticing events and interpretation is important for this study.

Van Es and Sherin (2002) highlighted two main aspects of noticing: identifying or attending to a particular event in the classroom and interpreting these events. The first part involves identifying moments worth noticing. Teachers need to be present in the class and attend to what their students are doing and saying. However, it is unrealistic to think that teachers can attend to everything happening in one lesson, so they must decide what they will attend to (Van Es & Sherin, 2002). This specifically relates to Research Question 1 of the current study: What focuses primary teachers' attention to notice moments meaningful to mathematical learning?

Van Es and Sherin (2021) later expanded on their conceptualisation of teaching noticing by suggesting that attending involves identifying moments worth noticing and knowing what parts of the classroom environment to disregard. *Selective attention* reflects the idea that teaching involves attending to some interactions while overlooking others, effectively identifying key events. What teachers do not notice can be just as important as what they do (Van Es & Sherin, 2021). Other researchers have also discussed this aspect of noticing. Erickson (2011) explored attending and disattending in his work on noticing. Selective attention is about how teachers decide to respond to some events and interactions while ignoring others (Santagata, 2011), which can occur for various reasons, such as a perceived lack of importance in certain events or interactions. By investigating what focuses teachers' attention, we can gain insights into the aspects of the classroom and teaching practices that facilitate noticing more meaningful moments.

Mason (2003) raised important questions about how practitioners become aware of noteworthy events. In his later work, Mason (2011) introduced the term *intentional noticing* emphasising that noticing is a more deliberate act rather than random. He used the term "to act freshly" to describe teachers noticing during classroom interactions:

> The discipline of noticing is a collection of techniques for (a) pre-paring to notice in-the-moment, that is, to have come to mind appropriately, and (b) post-paring by reflecting on the recent past to select what you want to notice or be sensitised to particularly, in order to pare , that is, to notice in-the-moment and so be enabled to act freshly rather than habitually. (Mason, 2011, p. 38)

The idea of *post-paring* suggests that teachers' reflections on classroom events can impact what they notice in the future. The current study centres on teacher noticing in the mathematics classroom, encompassing observing, interpreting, and responding to meaningful moments during learning. The concept of post-paring is particularly relevant to

this study, as it relies on teachers' reflections and recollections on their noticing of classroom events.

The skill of attending to students' mathematical strategies is often overlooked, as noted by Jacobs et al. (2010). It may be thought that all teachers possess this skill, and everyone sees the same details, but Jacobs et al. (2010) found that many participants in their study were unable to provide evidence of students' strategies. Much of the research on mathematics teacher noticing emphasises that teachers see classrooms through different lenses and that understanding these lenses can help scaffold teachers' abilities to notice (Jacobs et al., 2010).

The second part of noticing, as discussed by Van Es and Sherin (2002), involves interpreting the noticed events. Interpreting the events means trying to understand what was happening in that event, such as what a student or students were thinking or how the teacher influenced that thinking. These interpretations are important for deciding the next steps and informing future pedagogical decisions (Van Es & Sherin, 2002). While Star and Strickland (2008) focused solely on identifying noteworthy events in their work on noticing, the current study aligns with Van Es and Sherin (2002) in believing how teachers analyse what they notice can be just as important as what they notice.

In Jacobs et al.'s (2010) framework*, Professional Noticing of Children's Mathematical Thinking*, the interpreting component refers specifically to how teachers understand their students' mathematical strategies. They were interested in teachers' reasoning of the student's strategies and how well this reasoning aligned with the research on students' mathematical development. Jacobs et al. (2010) found that when participants were not focused on students' mathematical understanding, they discussed mathematics teaching and learning in more general terms. They caution that this shift to discussing mathematics more generally might indicate an avoidance of discussing students' understanding, potentially due to a lack of attention to these strategies or insufficient mathematical knowledge to interpret these strategies accurately.

In a study by Sherin (2017), it was stated that a noticed moment by a teacher typically does not stand alone as an isolated event; rather, it can influence what a teacher notices in the future. From a researcher's perspective, there is an inherent level of interpretation involved when identifying noticeable moments, and teachers often share this interpretation with the researcher as they recall the moment. This finding prompted Sherin (2017) to incorporate the aspect of interpreting into the construct of teacher noticing, underscoring the challenge of separating noticing from interpreting.

The skill of interpreting students' understandings, as discussed in both the *Learning to Notice* framework (Van Es & Sherin, 2002) and the *Professional Noticing of Children's Mathematical Thinking* framework (Jacobs et al., 2010), is an important aspect of informal formative assessment. Effective classroom observations and interactions rely on teachers' ability to interpret students' thinking, enabling them to provide feedback and adjust the learning when needed. By making sense of students' mathematical thinking, teachers are better equipped to make informed decisions and provide responsive teaching that promotes deeper mathematical understanding.

2.3.2 *Responding*

In Jacobs et al.'s (2010) construct, *Professional Noticing of Children's Mathematical Thinking*, three specific skills were identified. As well as attending to and interpreting student's thinking, they focused on how teachers decide to respond based on student's understanding:

> If instruction is to build on children's thinking, teachers must be able to: attend to children's strategies, interpret their understandings, and use these understandings in deciding how to respond. Furthermore, they must execute these three skills in an integrated way. (Jacobs et al., 2008, p. 192)

While researchers such as Van Es and Sherin (2002) argue that deciding how to respond occurs after noticing, Jacobs et al. (2010) believe it should be included as a part of noticing as it is strongly linked to the attending and interpreting of children's mathematical thinking. The current study aligns with this perspective, with Research Question 2 investigating "How do teacher's respond to what they notice?" Teachers can decide how to respond only once they have attended to students' strategies and interpreted the understandings reflected in those strategies. Jacobs et al. (2010) specifically focused on developing professional development for teachers that explores a framework of moves to develop teachers' practice of responsive teaching.

A more recent article from Van Es and Sherin (2021) explores an expanded framework of the construct of teacher noticing. Building on their previous work they extend the practice of teacher noticing to incorporate what they term *shaping*. Shaping is defined as the act of "creating interactions that provide increased opportunities to attend to and interpret noteworthy mathematical interactions" (p.17). During the act of noticing, teachers can construct interactions to gather additional information that further supports their noticing (Van Es & Sherin, 2021). The idea that noticing is an active, context-dependent process remains central. Shaping these classroom interactions allow for further attention and sense-making in-the-moment.

Sherin and Star (2011) stated that noticing was not a passive event that the teacher reflects on after it occurs rather, the teacher is constantly organising the environment to produce certain events worth noticing, akin to the idea of shaping (Van Es & Sherin, 2021) and intentional noticing (Mason, 2011). Teachers are a part of these events, not separate from them, and can actively shape what occurs to provide certain kinds of observations. This idea also aligns with the work of Jazby (2023), who reported that in an ecological approach to noticing, the classroom environment plays an important role. Using a perception/action cycle model highlighted how active classroom interactions and being in-the-moment can support teacher noticing. Teachers can use environmental structures to focus their attention and actively look for information (Jazby, 2016). Overall, these perspectives highlight that teacher noticing involves proactive engagement with the classroom environment to foster meaningful interactions that support ongoing observation and interpretation of students' mathematical thinking.

Jacobs and Empson (2016) use the term *responsive teaching*, a practice in which teachers' decisions about what to notice and how to respond are constantly changing in response to students' mathematical thinking. Their case study examined the *teaching moves* of one highly skilled teacher during classroom interactions aimed at supporting and extending students' mathematical thinking. Jacobs and Empson (2016) conclude by emphasising the importance of further attention to the parts of the lesson where teachers circulate and engage with students. They argued that effective responsive teaching hinges on strong teacher-student interactions within the classroom.

In a study by Jacobs et al. (2022), two forms of decision-making in response to student understanding were explored: deciding on follow up questions, where teachers focus on just one student's strategies and understandings and deciding on next problems where multiple students' strategies and understanding need to be considered. Their findings revealed that teachers demonstrated more expertise when deciding on follow up questions rather than next problems.

Teachers' noticing of students' mathematical thinking has received increased attention by researchers in recent years (Jacobs & Empson, 2016; Kazemi et al., 2016). The present study emphasises the importance of identifying moments that are meaningful to students' mathematics learning, particularly those that reveal students' mathematical thinking. Teachers can effectively build on students' thinking only after they have made sense of their existing thinking (Jacobs & Empson, 2016). Regardless of whether students' work is correct, partially correct or the thinking behind the answer just seems obvious, teachers still need to elicit what students are thinking. By actively listening to and observing what students say and do during tasks, teachers can respond appropriately and initiate

purposeful conversations based on this information (Jacobs & Empson, 2016). The insights gained from these classroom interactions, where teachers notice and make use of meaningful moments, can serve as a powerful form of informal formative assessment.

Developing their noticing skills enables teachers to gain insights into their practices, such as how teachers listen to their learners. Mason (2021) described teaching by listening as one of the six modes of interaction between the teacher, student, and mathematics. Teachers need to distinguish whether they are listening to what the learner is expressing or listening for an anticipated answer. The type of listening enacted by the teacher can influence actions or responses.

With education constantly changing and the recent reports of increased accountability, via statistical data collection processes, there is a growing need for further research to deepen our understanding of mathematics teacher noticing as a form of informal formative assessment. Lowrie et al. (2012) predicted future projects would investigate teacher practices in order to better understand the relationship between assessment practices and students' understanding. This study aimed to establish those connections by highlighting the practice of noticing as a key action of informal formative assessment in the mathematics classroom.

This study aimed to build on the existing research on teacher noticing by identifying what focuses a teacher's attention to noticing and responding to meaningful moments in the mathematics classroom and how this compares between the online context and the face-to-face context. The aim was to explore teacher noticing as a form of informal formative assessment from the teacher's perspective. While there is a substantial body of literature on mathematics teacher noticing, existing studies linking it to assessment primarily focus on assessing or developing teachers' noticing abilities (Jacobs et al., 2022; Sherin, Russ, et al., 2011). However, this study concentrated on how teachers can integrate teacher noticing as a daily assessment practice to gather evidence to enhance student learning.

The following sections will examine current literature published since the COVID-19 pandemic to ascertain existing knowledge about online learning during ERT.

2.4 Online Learning in ERT

The COVID-19 pandemic (2020-2022) led to the biggest interruption to global education in modern history with more than 1.5 billion students' education being disrupted. Widespread lockdowns early in 2020 lead to the swift change from face-to-face teaching to online learning. In Australia, this led to most states spending the majority of Term 2 in

lockdown. Victoria, however, spent longer in lockdown not returning to face-to-face teaching until early Term 4.

In conducting a search for literature published about online learning since the COVID-19 pandemic began it became apparent that the majority of the literature was based at the tertiary education level (Adedoyin & Soykan, 2023; Donham et al., 2022; Ezra et al., 2021) with minimal research from the context of primary schools. Although there was a range of research literature from across the globe (Beattie et al., 2022; Potyrała et al., 2021; Shamir-Inbal & Blau, 2021), the research literature in Australia was limited.

For students in metropolitan, regional and rural schools, online learning was a new concept that became known as Emergency Remote Teaching (ERT) and will be the term used throughout this study. ERT is defined as "a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances" (Hodges et al., 2020, p. 6). ERT differs from distance or online learning which is defined as "instruction through print or electronic communications media to persons engaged in planned learning in a place or time different to that of the instructor" (Gunawardena & McIsaac, 2013, p.358). There have been many identified benefits to online learning including saving time, flexibility in terms of time and location of study, the possibility of saving money, and not having to commute in traffic or on crowded public transport (Clark & Mayer, 2016; Sadeghi, 2019). Limitations to learning online include a lack of resources, limited space for learning at home, limited social interaction, and lack of self-motivation (Sadeghi, 2019).

Distance learning has been a part of the Australian education system for decades, providing education for students in rural and remote locations (Lowrie, 2007; Stevens, 1994). More recently, literature has focused on technological advancements in distance learning, such as the introduction of satellite-supported, two-way broadband internet services (Crump & Boylan, 2008). However, ERT differs from distance learning and online learning in that it was put in place quickly at a time of need under emergency circumstances.

2.4.1 *Engagement Online*

Student engagement has long been a focus of many studies, with extensive literature exploring this topic for decades (Attard, 2012; Fredricks et al., 2004; Pianta et al., 2012). However, engagement literature around online learning has traditionally centred on adult learning and designing courses specifically for online delivery. The COVID-19 pandemic prompted a shift, bringing attention to how school aged children engaged in online learning during this period (Aguilar et al., 2022; Bissessar, 2021; Khlaif et al., 2021). Research has highlighted that student engagement and participation significantly impacted learning and performance in online learning during ERT (Khlaif et al., 2021).

Over the years, researchers have used different definitions of student engagement. For example, Bond (2020) defined student engagement as,

> The energy and effort that students employ within their learning community, observable via any number of behavioural, cognitive, or affective indicators across a continuum. It is shaped by a range of structural and internal influences, including the complex interplay of relationships, learning activities and the learning environment. The more students are engaged and empowered within their learning community, the more likely they are to channel that energy back into their learning, leading to a range of short and long term outcomes that can likewise further fuel engagement. (Bond et al., 2020, p. 3)

Using previous definitions, Khlaif et al. (2021) described engagement in ERT as,

> attending online sessions (synchronously and asynchronously), communicating with peers and the instructor, participating in the online class activities, being a knowledge producer (recording a short video to explain an idea, designing a PowerPoint presentation) and the efforts that students make in their learning environment. (p. 7036)

In a study by Cao et al. (2021), 152 primary and secondary teachers were interviewed about their experience with teaching mathematics online during the pandemic. Participants reported that online teaching was as effective as traditional teaching for those who were engaged, independent and willing to learn, but not for those who lack the motivation or the skills to manage their own learning. Similar findings were reported by Bissessar (2021) and Sullivan et al. (2020), indicating that that students who were previously motivated and engaged in the face-to-face classroom were able to transfer these skills to learning online during ERT. Before entering ERT, it was unknown how students would engage with this new way of learning.

However, a different perspective emerged from Kim and Asbury (2020) who interviewed 24 teachers from English state schools about their experiences teaching online during the COVID-19 pandemic. They discovered *surprise stars*, students who had not previously stood out in the face-to-face classroom but had “shone” during online learning (Kim & Asbury, 2020, p. 1075). Reflecting on noticing a *surprise star* online, one participant in this study noted “I think I will approach that student in a very different way now”.

Three main issues have been identified when considering engagement online during ERT: lack of interactions, the challenge of differentiating effectively, and parental involvement. Ferri et al. (2020) conducted a study that involved an online discussion forum

with experts from different countries and sectors. They found that the lack of social interaction was strongly linked to decreased engagement in ERT. Their thematic analysis revealed that student engagement could be enhanced through informal social activities, like online games or social chat platforms. Many studies since the COVID-19 pandemic have reported the loss of student-teacher and student-student interactions as one of the most significant challenges of ERT (Cao et al., 2021; Ferri et al., 2020; Kalogeropoulos et al., 2021; Russo et al., 2021). Cao et al. (2021) reported that more than half of their study participants struggled to adapt their teacher-student interactions to the online environment, without some level of verbal communication, eye contact, or non-verbal cues available in physical classrooms.

Russo et al. (2021) identified two major challenges associated with allowing students to struggle in remote learning settings: “absence of a teacher-facilitated, synchronous learning environment … lack of social connection and peer-to-peer collaboration” (p. 1). Participants felt that classroom-based settings allowed for close monitoring and support, which was difficult to reproduce online. During ERT, schools were using a range of virtual learning platforms, for example, Zoom, Google Classroom or Webex; however, interacting through these platforms provided only limited information for the teacher (Russo et al., 2021).

Khlaif et al. (2021) emphasised the importance of teacher presence during ERT for scaffolding, providing more detailed instruction about set tasks, and engaging students. Teachers used different communication tools like Zoom or Google Classroom, to answer students’ questions, assist students who were having difficulties, and reduce the feeling of isolation for students during ERT. However, the lack of real-time interactions and feedback posed significant challenges (Kalogeropoulos et al., 2021; Potyrała et al., 2021). Delays in communication, such as waiting for email replies or feedback were noted as problematic. One participant in Potyrała et al. (2021) study commented, “A three-minute reaction often changes to a matter of three days.” (p. 7463).

Live online instruction is important in engaging students and fostering connectedness between teachers and peers (Aguilar et al., 2022; Kalogeropoulos et al., 2021). In response to feedback, one participant in a study by Kalogeropoulos et al. (2021) reported adjusting their remote learning structure to include more synchronous sessions, attempting to reproduce the live classroom environment. These synchronous learning sessions provided more opportunities for teacher-student and student-student interactions in ERT.

Aguilar et al. (2022) also found a strong correlation between live instruction and student engagement in online learning environments. After surveying 1181 southern Californian families at the end of their 2019/2020 school year, they calculated the number of

minutes of live instruction students received per week. Using students' completion of schoolwork as an outcome measure, they found a strong correlation between live instruction and student engagement during ERT.

Strong parent-teacher relationships have long been considered important to students' school experiences (Vickers & Minke, 1995). Unsurprisingly, this theme emerged from the literature published on the impact of the COVID-19 pandemic. Many studies recognised the increased responsibility placed on parents and guardians during ERT (Beattie et al., 2022; Garbe et al., 2020; Lepp et al., 2021). Given parents are important stakeholders in their child's education, Garbe et al. (2020) surveyed 122 parents on their experiences and struggles during school closures. Parents reported feeling well supported by the school but faced challenges with accessibility, learner motivation and balancing responsibilities.

Parents also greatly impacted student engagement during ERT. Sullivan et al. (2020) found that some parents may have become more involved in their child's education during ERT, taking their role as home tutors seriously and deeply engaging with their children's learning. Sullivan et al. (2020) suggested the need to continue broadening the nature of home learning experiences long after ERT.

Teacher participants in a study by Beattie et al. (2022) also highlighted the substantial influence parents had in reinforcing their child's engagement during ERT. Participants reported both positive and negative influences, with reports of home pressures affecting parents' availability to support their children. Based on their findings, increased communication between parents and teachers during ERT was recommended (Beattie et al., 2022).

Downton et al. (2022) and Russo et al. (2021) also found communication with parents to be vitally important during ERT. When considering the use of open-ended tasks during ERT, findings revealed parents were unfamiliar with these types of tasks and found it challenging to help their child when they were struggling. Reflecting on this, teachers considered the information may need to be provided to parents about the nature of these tasks and the importance of allowing their child to struggle as part of the learning process (Downton et al., 2022; Russo et al., 2021). Maintaining a strong partnership with parents and involving them in their children's mathematics learning was crucial during ERT.

Interestingly, Kim and Asbury (2020) noted increased trust between teachers and students during ERT through analysis of their participants' stories. They concluded that strong parent-teacher relationships, where both parties aligned, may prove beneficial on return to the face-to-face classroom.

2.4.2 *Teaching Mathematics Online*

Recently, a range of studies have examined the challenges teachers faced teaching mathematics online (Cao et al., 2021; Kalogeropoulos et al., 2021; Sullivan et al., 2020). Key challenges in the online environment included, effectively catering to the needs of all students, creating quality tasks for the online environment that were similar to the classroom, and fostering classroom interactions where you could monitor and assess the learning.

How teachers would adapt their mathematics lessons and transfer the learning to the online environment was unknown. Sullivan et al. (2020), noted that lessons involving demonstrations followed by practice were relatively easy to adapt lessons to the online environment due to the availability of online resources like videos and games. Explicit instruction and repeated practice, which are pedagogical approaches in mathematics, were considered particularly suitable for the online learning environment, because they were more easily integrated with the use of video technology online. However, solely relying on these approaches during ERT posed threats, such as a lack of interest, less targeted practice, and limited opportunities for students to engage deeply with mathematical concepts (Sullivan et al., 2020).

Transferring inquiry-based or similar teaching practices to the online environment proved more challenging (Kalogeropoulos et al., 2021; Sullivan et al., 2020). In a study conducted by Kalogeropoulos et al. (2021) two teachers from schools known for their inquiry-based practices shared their experiences. Through semi-structured Zoom interviews, they discussed their efforts to align online mathematics learning with their school's teaching philosophy and their own teaching styles. A major challenge was catering to all students with the tasks they provided, as anticipating how each student might go with the task and how to cater for it in advance was difficult (Kalogeropoulos et al., 2021). In the face-to-face classroom, teachers could make "on the fly" adjustments if a task was too easy or too difficult for a student.

Beattie et al. (2022) also highlighted differentiation of learning as a significant challenge during ERT. Participants in their study reported difficulties in providing tasks that met individual learning needs and felt unable to provide the same level of support that they could in the face-to-face classroom environment, potentially leading to decreased student motivation. Some participants expressed concern in addressing students' wellbeing needs in addition to their education support.

2.4.3 *Teacher Noticing Online*

In an article written before the COVID-19 pandemic, Campbell (2018) aimed to synthesise the literature on teacher noticing and, in doing so, made recommendations for

future research. He suggested one area for inquiry, how the context in which a teacher works, affords, or constrains the enactment of noticing and responsiveness. The current study, conducted during the COVID-19 pandemic while teachers and students were involved in ERT, explored the new context of online learning. Specifically, Research Question 3 investigated: Regarding mathematics learning, how does what teachers notice and respond to in the online context compare with the face-to-face context?

Since the pandemic began, a range of literature has been comparing online learning (ERT) to face-to-face classrooms and other delivery methods (Cao et al., 2021; Kalogeropoulos et al., 2021; Sullivan et al., 2020). Although we know little about how the construct of teacher noticing was transferred to the online environment, it is known that one of the biggest challenges for teachers in ERT was the lack of opportunities for student-student and student-teacher interactions (Ferri et al., 2020; Kalogeropoulos et al., 2021; Russo et al., 2021) where teacher noticing typically occurs. Some schools adjusted the structure of their online learning in the second phase of ERT to incorporate more synchronous learning opportunities (Cao et al., 2021; Kalogeropoulos et al., 2021). Synchronous learning referred to lessons conducted online where students were on at a set time to complete a task, or part of a task, together with the teacher. While these live teaching sessions did not fully reproduce the face-to-face classroom experience, they did provide teachers with more opportunities for noticing online.

DeCoito and Estaiteyeh (2022) reported that many teachers found their online assessment practices unauthentic and ineffective. Interestingly, some teachers in their study reported that their schools prohibited graded assessments during ERT. Their comments revealed that not only did one teacher not consider feedback an assessment strategy, but that many reported their online assessment practices as invalid since they were all ungraded. However, other participants reported success with various formative assessment practices online, such as using rubrics and providing feedback, and expressed their intentions to utilise these strategies when back in the face-to-face classroom after ERT (DeCoito & Estaiteyeh, 2022).

A study by Panadero et al. (2022) also reported changes in teachers' assessment practices during ERT. One notable finding was that while secondary teachers reported an increase in feedback during ERT, primary teachers reported a significant decrease. This decrease may be understandable given the lack of opportunities for student-student and student-teacher interactions, as teachers often rely on direct observation to provide effective feedback (Panadero et al., 2022).

Previous studies have emphasised the importance of interactions and monitoring learning during instruction (Cao et al., 2021; Clarke, 2004), which raised questions for Cao et al. (2021) about whether there can be an equivalent lesson event in the online context.

2.5 Summary

The aim of this chapter was to present a review of the literature relevant to this study. The chapter began with a discussion about mathematics teaching and learning practices, focusing on social constructivist learning as the theoretical position underpinning this study. In the section that followed, significant literature related to formative assessment was examined more closely, with an emphasis on informal formative assessment and how information gained through these assessments can be used by both students and teachers to improve the teaching and learning of mathematics. There is a recognised need for assessment practices that are more closely aligned with the pedagogical approaches of a social constructivist learning environment that can be implemented as a part of a teacher's daily classroom practice. A review of the literature highlighted the importance of effective classroom interactions and the impact they can have on student learning. During these classroom interactions teachers can monitor and adjust the learning where needed.

Researchers such as Jacobs et al. (2010) and Van Es and Sherin (2002) contributed insight into the construct of noticing, including what teachers attend to, how they interpret what they notice and how they respond. Teacher noticing, as an act of informal formative classroom assessment, provides opportunities for teachers to notice students' mathematical thinking and check students' level of understanding. There remains potential for further study on teacher noticing as an effective informal formative assessment practice that can be embedded into daily classroom interactions.

Given the context of this study, a range of recent literature on online learning was also examined, particularly those published since ERT. Adapting teacher practices to the online environment posed challenges, including the lack of interactions, difficulties in providing real-time feedback, and the challenge of assessing students' learning effectively. Of particular interest was how the practice of teacher noticing translated to the online environment and how teachers' observations and responses differed between the online and face-to-face environments. Notably, there is limited research on teacher noticing in online contexts, but it is evident that the reduced opportunities for teacher-student and student-student interactions make it challenging to observe and respond to students' mathematical thinking effectively.

In the next chapter, Chapter 3, the research design for this project will be discussed in detail.

Chapter 3: Methodology

3.1 Introduction

The complexity of events in classrooms often makes particular phenomena difficult to study. Thinking about the judgements that teachers make about students' mathematical knowledge and reasoning in their everyday classrooms necessitated investigating teaching and learning events through teachers' perspectives. This study aimed to investigate teachers' reflections of noticing as a critical action of informal mathematics assessment from the teacher's perspective, and to identify what teachers notice that is meaningful for mathematical learning in different contexts and how the information gained through these moments can be used to enhance student learning.

The most suitable way to study the phenomena was considered to be by asking teachers to describe their perceptions of classroom events and their interpretations of them. Qualitative researchers often take on an interpretive perspective where they assume that people create their own meaning through interaction with the world around them (Braun & Clarke, 2013). There is no unitary reality because each individual is unique and cannot be averaged to explain a phenomenon. This also applies to the researcher themselves, who is also unique, and this can have an effect on the research itself. The researcher will generally ask open questions about participants' experiences and will allow questions to emerge and change as needed. Through this approach the researcher acknowledges that reality is constructed through the meaning individuals give to a particular phenomenon (Braun & Clarke, 2013). Merriam and Grenier (2019) also stated that to understand qualitative research meaning needs to be socially constructed by individuals interacting with their world.

The current study is based on teachers' self-reports, similar to a study by Solheim et al. (2018), who investigated ways teachers can improve their interactions with students. They stated that teachers are important agents in shaping education and bringing about change in educational practices. Through surveys, interviews, and digital logs, three aspects of classroom interaction were addressed: emotional support, classroom organisation and instructional support (Solheim et al., 2018). Teachers' responses demonstrated emotional support through their connections and relationships with teachers and students. Relationships also emerged as a theme under classroom organisation, with teachers highlighting the need for clear communication and mutual respect between teachers and students. Despite fewer examples of instructional support, teachers were able to reflect and learn from each lesson taking into consideration the learning process and success of the lesson.

This research project used qualitative research methods to investigate three main research questions:

1. What focuses primary teachers' attention to notice moments meaningful to mathematical learning?

2. How do teachers respond to what they notice?

3. Regarding mathematics learning, how does what teachers notice and respond to in the online context compare to the face-to-face context?

In this chapter, the study design, participants, data collection methods and analysis, and trustworthiness of the research are described.

3.2 Research Design

This research project was conducted using a general qualitative approach to investigate teachers' perspectives of noticing as a key action of informal formative classroom mathematics assessment.

In adopting a qualitative approach grounded in an interpretivist epistemological view (Walter, 2019), this study focuses on understanding the subjective experiences and meanings constructed by individuals within their social contexts. The interpretivist approach is philosophically oriented toward capturing these personal meanings, emphasising that reality is socially constructed and best understood from the perspectives of those who experience it (Walter, 2019). By focusing on depth, context, and the uniqueness of each individual's perspective, interpretivism seeks to provide insights into the complexities of human behaviour and social interactions. This approach highlights the researcher's role in interpreting data through the participants' lens, gathering rich, detailed narratives that capture the intricate nature of human experience. The goal is to explore the subtleties within these experiences and identify the contextual influences shaping them, supporting a holistic understanding that values the diversity of individual perceptions and realities.

Eight teachers from seven different primary schools were invited to participate in the study. Teachers known to have an interest in mathematics were recruited as interviewees for this research project.

The research was conducted during the COVID-19 pandemic in 2020 that required online teaching and learning for a period during the data collection. This meant that changes were made to the study due to the pandemic which saw the search for teachers to participate widened. As such the eight participants in the study were a convenience sample based on the current situation (Lunneborg, 2007). Convenience sampling is a type of

nonprobability sampling that involves a group that is easily accessible to the researcher. As the name suggests convenience samples are more easily obtained.

A social constructivist lens was employed for this study to explore how individuals construct knowledge and make meaning within their social contexts. This view emphasises the importance of social interactions and shared experiences in shaping our perceptions and behaviours (Kalina & Powell, 2009). Adopting a social constructivist lens allows the researcher to delve deeply into the experiences of participants providing a rich, contextualised understanding of the phenomenon under study.

3.3 Human Research Ethics Approval

Approval from the Human Research Ethics Committee (Project ID: 23609) was first obtained for this study early 2020. The original research design included individual interviews with teachers together with classroom observations. However, due to the COVID-19 pandemic researchers were unable to obtain permission to enter schools for data collection. It was during this time that decisions were made to adapt the data collection methods for the study. An amended Ethics Application was submitted to MUREC to seek approval for two interviews to be conducted with each participant two months apart. Approval was obtained in September 2020 (see Appendix A). The interviews were still to be conducted individually however would be conducted and recorded in an online environment rather than face-to-face at the teachers' schools. Further information about these interviews can be found later in this chapter.

3.3.1 *Ethical Considerations*

It should go without saying that all research should be of the highest ethical standard, and this does connect with the ethical stance of the researcher (Merriam, 2015). Ethical considerations early in the study include obtaining informed consent and maintaining privacy and confidentiality. In this study, thorough information was provided to the participants before they consented which also included information about the storing of the data from the study as well as understanding their right to withdraw at any time (Braun & Clarke, 2013) (see Appendix B).

3.3.2 *Recruitment of Participants*

Once Human Research Ethics approval was obtained participants were recruited. Participants were chosen via network sampling. Network sampling involves identifying groups or participants that may be referred by people you know or may be particular cases of interest (Merriam, 1998). The aim was to find interested participants through the researcher's professional networks such as Numeracy Networks and participants in previous

projects such as reSolve (https://resolve.edu.au/). ReSolve is an education program from the Australian Academy of Science. They promote *Maths by Inquiry* and provide teaching resources and professional learning materials to support teachers in implementing this program in schools. The reSolve protocol sets out a vision based on three main focuses: that the mathematics is purposeful, the tasks are challenging, and that classrooms have a knowledge-building culture. These pedagogical practices link strongly to the factors that were being considered as selection criteria for participants in this study. The researcher was involved in a twelve-month professional learning program called *Leading ReSolve* in 2015 which equips participants with the skills and knowledge to help others engage with the program. It was during this time that the researcher made connections with mathematics teachers and leaders also involved in the program. This is just one example of connection with a professional network.

In this study, teachers were sent an email directly from the researcher inviting them to participate. In this email, an explanatory statement for the study was attached (see Appendix B) outlining the main aims and what would be involved for them as a participant, and a consent form was provided (Appendix C). The explanatory statement reflects the original project design. Participants were notified by email of the changes, which were reflected in the consent form. As participation was voluntary and interviews were conducted outside of school hours approval, from the school's principal was not required. It was explained to teachers that their participation was voluntary and that they would retain anonymity. All eight teachers who were approached agreed to participate in the study. Table 1 shows information about the participants. All teachers worked in years three to six and two teacher had a mathematics leadership role in their school. The participants were three Year 5/6 teachers (students aged 10-12 years), two Year 5 teachers and three Year 3/4 teachers (students aged 9-10 years). The two Year 5 teachers worked part-time and shared teaching of the same class. This is called a "shared grade" where one class has two teachers. In this situation Belinda (pseudonyms are used throughout) worked three days a week (Monday, Tuesday, Wednesday) and Narelle worked two days a week (Thursday, Friday). All eight participants were primary school teachers at suburban government schools in Melbourne, Victoria.

Table 1

Information About Participants of Research Study

Teacher	Year Level	Part time/Full Time	Mathematics Leader
Sarah	5/6	F	No
Greg	4	F	Stem Leader
Jennifer	3/4	P	No
Lisa	5/6	F	No
Andrew	3/4	F	Yes
Belinda	5	P	No
Narelle	5	P	No
Kate	5/6	F	Yes

3.4 Data Collection

The COVID-19 pandemic led to a period of time that required online teaching and learning. This period of time was often referred to as *remote learning* by schools. Remote learning is defined by the "TeachThought" site as "a temporary move from face-to-face learning in a physical classroom to learning online" (TeachThought, 2024, para. 1) This definition differs from *distance learning* which is traditionally defined as "instruction through print or electronic communications media to persons engaged in planned learning in a place or time different to that of the instructor" (Gunawardena & McIsaac, 2013, p. 358). In this study, the term ERT has been used in place of remote learning and will continue to be used throughout this chapter.

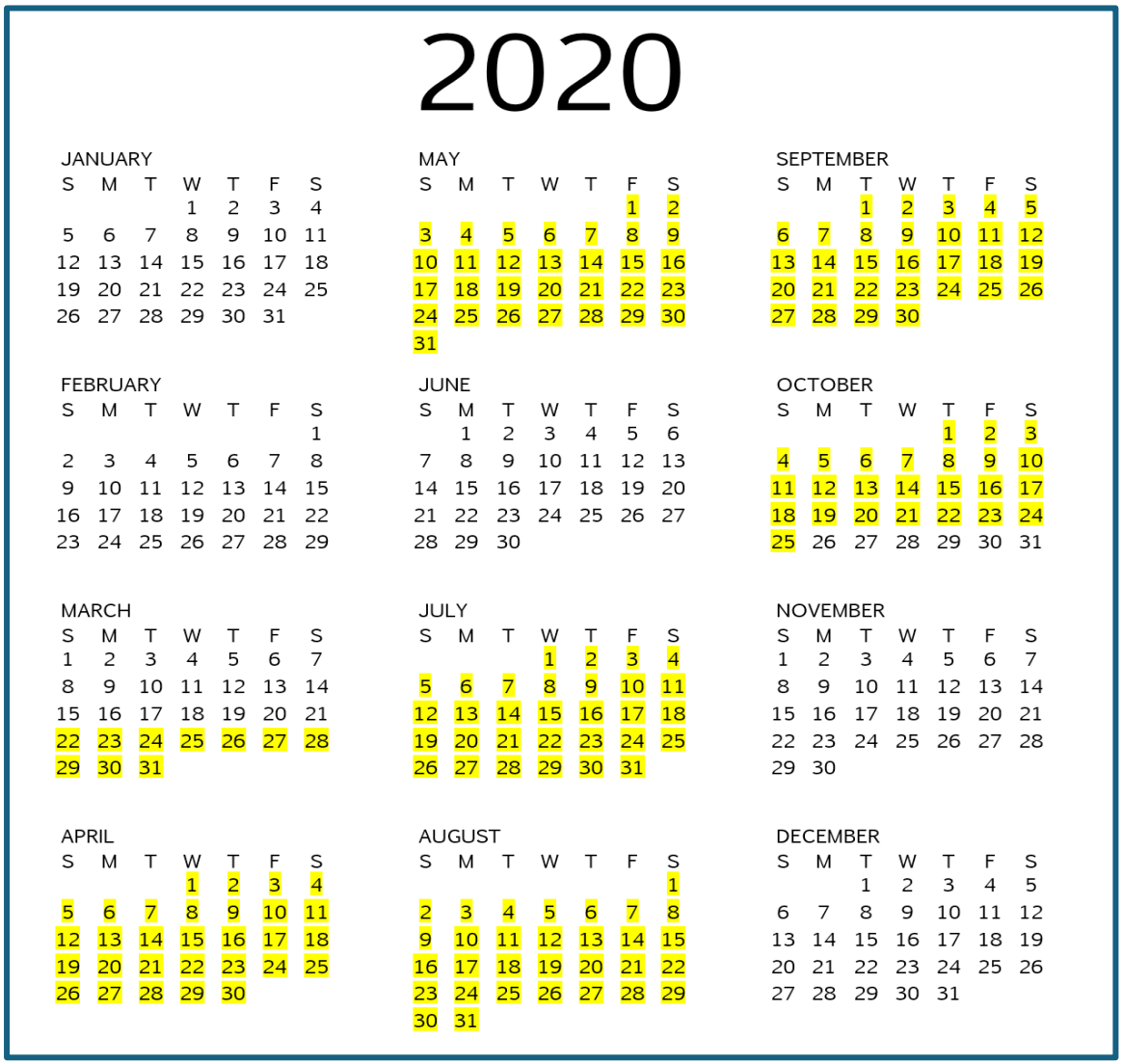
During ERT schools used eLearning tools to activate online learning for primary students in Victoria state schools while they could not be in the classroom. It is important to note that there were some students who did not have access to the eLearning tools necessary to participate in ERT. Schools were providing hard copy packs of work for these students and delivering them to their homes.

There were two COVID-19 lockdowns for state schools in Victoria, Australia, in 2020 that resulted in ERT for students in these schools (see Figure 1). The first time was at the start of Term 2 (April 2020). Students and teachers spent 37 days in ERT before returning to the classroom on the 9 June 2020. After only a few short weeks school were required to

lockdown again, and ERT began at the start of Term 3 (July 2020). Students spent 50 days in ERT this second lockdown in 2020. These two periods of ERT were referred to as *phase one* and *phase two*. During the time of ERT, teachers were guided by advice from the Department of Education and Training (DET). DET created a site, "Learning from home in a school setting", that provided advice for schools about how they can ensure learning continuity during periods of disruptions due to COVID-19. (State Government Victoria, 2020)

Figure 1

Dates of School Lockdowns and Remote Learning in 2020



Interview data were collected from eight teachers on two separate occasions: firstly, during ERT in Term 3 (Interview 1) and secondly, when teachers and students had returned to the physical classroom environment in Term 4 (Interview 2). The interviews sought to understand what focuses teachers' attention to notice meaningful moments whilst teaching mathematics remotely and face-to-face in the classroom.

Semi-structured interviews were conducted online with each participating teacher. Six interviews were conducted individually, and one interview was conducted with a pair of teachers. The pair of teachers shared responsibility for a class of students by dividing the week with one teaching three days and the other teaching two days. There was an interval of time between Interview 1 and Interview 2 of approximately two months.

3.4.1 *Interviews*

The purpose of interviewing is to understand another person's perspective. Qualitative interviewing begins with the view that other's perspectives are meaningful (Patton, 2002). Through interviewing my chosen participants, I aimed to find out what was in and on their mind and to gather the stories they had to share.

Patton (2002) referred to "rapport and neutrality" as an interviewer. As the researcher, I had professional relationships or connections with seven out of eight of my participants through having worked together in the past or having met at a professional network. Rapport was already established, and the participants were able to tell me anything and openly share stories. As is discussed by Patton (2002), it is important that the researcher conveys to the interviewees that what they have to say is important and they will not be judged on their responses. The seven participants know I am passionate about the teaching and learning of mathematics, that I care, and I am very interested about what my participants have to say.

According to Patton (2002) there are three different ways in which to collect qualitative data through interviews: Informal conversations as interviews, the general interview guide (semi structured interviews) and the standard open-ended interview. Each of these ways of interviewing is used for different purposes. The interview style that was chosen to collect data in this study was the general interview guide which will be discussed in detail in the next section.

3.4.1.1 The General Interview Guide Approach. A general interview guide has a list of questions or issues to be explored during the interview to ensure that the same basic topics are discussed with each participant. A conversational tone can be built allowing spontaneous questions to be worded and although there is a pre-determined focus, questions can be adapted or their order of presentation can be changed (Patton, 2002). When interviewing a number of people, the use of a general interview guide helps to make interviewing more systematic and to keep to a time frame. The guide can still be as detailed as the interviewer chooses (Patton, 2002).

According to Patton (2002) there are six kinds of questions that can be asked during interviews:

- Experience and behaviour questions
- Opinion and values questions
- Feeling questions
- Knowledge questions
- Sensory questions
- Background/demographic questions. (p. 136)

The interview questions in this study related mainly to the teachers' experiences in recent mathematics lesson and their descriptions of the behaviours of the students in their classrooms. However, they could also be considered knowledge questions as teachers were required to draw on their knowledge of the teaching and learning of mathematics and their prior knowledge of the students in their classes. For example, in Interview 1 question three asked: *Can you tell me something you have noticed about a student (or students) during remote learning?* In Interview 2 question four asked: *Can you tell me something you have noticed about a student that was surprising or interesting (in relation to mathematics)?* These two questions gave teachers the opportunity to describe particular behaviours they had noticed in their students. In order to answer this question teachers may have also used prior knowledge of their students when discussing what they had noticed. Having similar questions for both Interview 1 and Interview 2 allowed for a comparison between the two learning environments, the online setting during ERT and the face-to-face classroom after ERT.

Questions can be asked in the past, present or future tense. Primarily this study used the past tense as the teacher-participants were either describing what had happened previously in their online interactions with their students as they were learning mathematics or what had happened on return to face-to-face teaching. Teachers were being asked to recall events from previous online or face-to-face experiences around the teaching and learning of mathematics with their students.

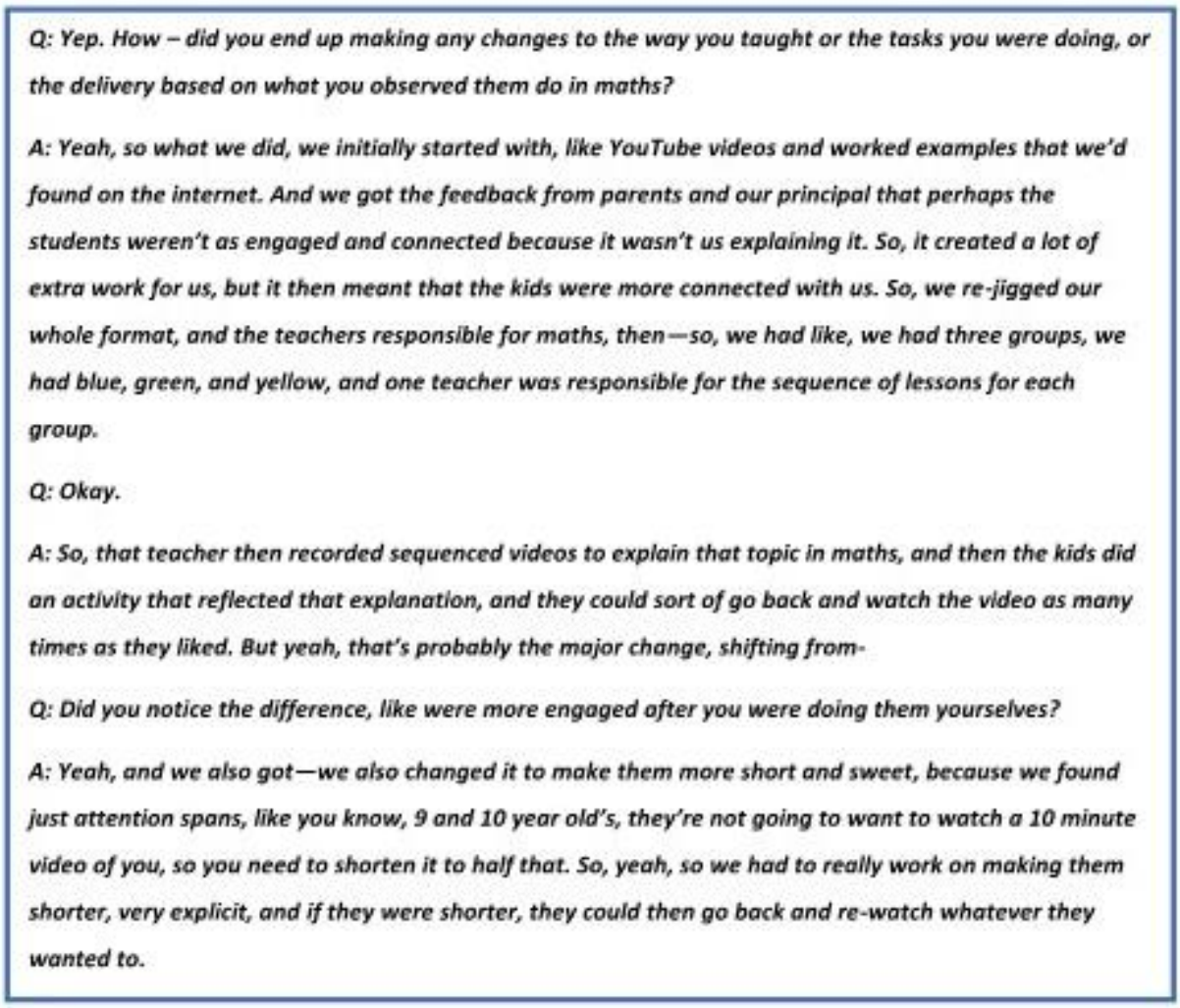
A semi-structured style of interviewing was chosen for this research project to allow for flexibility of wording in a conversational style and a mix of more and less structured questions (Merriam, 2016). Using semi-structured interviews, the interviewer is free to ask questions, explore a response further or to delve deeper into an issue. All of the questions

asked during the interviews in the study were open-ended, as they did not assume or predetermine any one answer, which is a style described by Merriam (2016). An open structure allowed the interviewee to take any direction they chose and express what they wanted to say, and how they wanted to say it. As answers to these questions were based on recent teaching both online and face to-face, teachers were able to recall a particular moment and a share a story with the researcher. Often during these interviews, participants were able to recall more than one specific moment and were eager to share more than one story.

Due to the semi-structured nature of the interviews in this study further questions were asked depending on the participant's answer for any given question. In response to a participant's answer, it was possible to seek clarification or to ask for further elaboration of the answer, or to ask for an example to illustrate the point they had made. In this way, the interview structure allowed for flexibility and a conversational style. For example, Figure 2 shows an excerpt from a transcript where the interviewer asks a question (Question 2, Interview 1) to which the participant responded. The researcher then followed up with a clarifying question in order to gain further information. As stated by Merriam (2016), follow-up questions enable the interviewer to probe the interviewee and to gather data in greater detail and depth. In each of the transcripts in this study the letter "Q" has been used to show when the interviewer was speaking, and the letter "A" has been used to show when the participant was speaking.

Figure 2

Example of Extended Question



Q: Yep. How – did you end up making any changes to the way you taught or the tasks you were doing, or the delivery based on what you observed them do in maths?

A: Yeah, so what we did, we initially started with, like YouTube videos and worked examples that we'd found on the internet. And we got the feedback from parents and our principal that perhaps the students weren't as engaged and connected because it wasn't us explaining it. So, it created a lot of extra work for us, but it then meant that the kids were more connected with us. So, we re-jigged our whole format, and the teachers responsible for maths, then—so, we had like, we had three groups, we had blue, green, and yellow, and one teacher was responsible for the sequence of lessons for each group.

Q: Okay.

A: So, that teacher then recorded sequenced videos to explain that topic in maths, and then the kids did an activity that reflected that explanation, and they could sort of go back and watch the video as many times as they liked. But yeah, that's probably the major change, shifting from-

Q: Did you notice the difference, like were more engaged after you were doing them yourselves?

A: Yeah, and we also got—we also changed it to make them more short and sweet, because we found just attention spans, like you know, 9 and 10 year old's, they're not going to want to watch a 10 minute video of you, so you need to shorten it to half that. So, yeah, so we had to really work on making them shorter, very explicit, and if they were shorter, they could then go back and re-watch whatever they wanted to.

3.4.1.2 The Interview Questions. Interview 1 was conducted during remote learning and Interview 2 was conducted when teachers had returned to face-to-face teaching. Four main questions were used in each interview. The key questions structuring the conversation in Interview 1 were:

1. When thinking about mathematics, what has been one of the biggest highlights for you in remote learning? Who was involved?

2. What changes have you made to your mathematics teaching/tasks/delivery based on what you have observed of your students during remote learning?

3. Can you tell me something you have noticed about a student (or students) during remote learning (in relation to mathematics)?

4. When thinking about the teaching and learning of mathematics, how has a student surprised you in remote learning?

The four key questions structuring the conversation in Interview 2 were:

1. What has been a highlight for you today or recently in a mathematics lesson? Who was involved?

2. Have you noticed any changes since returning to school (thinking about the students, your teaching, the classroom environment in relation to mathematics)?

3. Can you tell me about a recent mathematics lesson?

4. When thinking about mathematics, can you tell me something you have noticed about a student that was surprising or interesting?

The two interviews were designed together at the outset of the study. A structure was devised where each of the four questions was matched to its equivalent in the two interview guides.

After Interview 1 was completed the structure and the content of the Interview 2 was reviewed and evaluated. Careful consideration of the data from Interview 1 led to the decision to keep the original format and content. A preliminary examination of the data indicated that responses to the interview questions would potentially answer the research questions posed by the study.

Interview 1 was conducted in 2020 in late September/early October while teachers were in the last weeks of ERT before preparing for a return to the classroom. At the time of the interviews the participants had some experience with remote learning and had made changes in phase two of ERT based on what they learned in phase one. At the beginning of each interview, there was some initial informal discussions with each of the participants before asking the four main interview questions. During this conversation I asked the participants *"How is remote learning going?"* It was during these discussions that participants shared their stories of the ERT experiences so far. Included in these stories were changes that had been made to ERT over time including the addition of more "live" teaching lessons where students were directed to be online at a specific time for a particular lesson.

Interview 2 was conducted late in November after teachers had returned to face-to-face teaching and had been back in the classroom for approximately three to four weeks.

3.4.1.3 Online Interviews. Recent technology that allows us to conduct interviews online certainly has its advantages including overcoming time, geographical or financial constraints. However, there are still possible areas for concern including a disruptive environment or issues with internet connections (Janghorban et al., 2014). Gray et al. (2020)

agree that online interviews using a video conferencing program are a cost-effective and convenient alternative to face-to-face interviews. Although the advantages of these programs have been well documented using the programs as a data collection method are still to be thoroughly explored.

All interviews were conducted using Zoom, an online platform where users have access to video teleconferencing software to communicate. Zoom has some advantages over other platforms in that it is free to use and does not require participants to have an account or to download a program (Gray et al., 2020). The electronic meeting invitation that Zoom creates can be edited by the researcher to include specific information about the interview for the participant. Zoom has screen-sharing abilities that allowed both the researcher and the participants to display documents, images or video clips that might start a conversation (Gray et al., 2020). Although there was no plan to use this feature, in several interviews participants asked to share their screen document with the researcher. Zoom also has a recording feature. The program automatically saves two versions of the recording: a combined audio video and one just audio. Zoom also allows for individual choice with being recorded. All interviews were recorded via Zoom for analysis. If a participant does not wish to be video recorded for privacy reasons an audio only option is available. In this study, all fourteen interviews were recorded using combined audio and video with the participants' permission. Some participants shared their screen during the interview, and this was captured on the recording. I did not feel it was necessary to take notes during the interviews because the software was keeping complete records of events. This allowed me to be present in the interview without any distractions.

The video interviews were designed to take 30 minutes although the timing was flexible, and each teacher was able to choose a day and time that was convenient for them.

3.5 Data Analysis

Data analysis in qualitative research begins soon after data collection and the two actions—collection and analysis—can often run together or overlap as was the case in this study (Patton, 2002). It is important to note that due to the new situation we were faced with, school closures due to the COVID-19 pandemic, an inductive approach to analysis was taken. The steps involved in the analysis process of this study were:

1. Note taking (memoing) was completed between each individual interview and recorded in a journal

2. Recordings of each interview were transcribed

3. Thematic analysis was conducted of the interview transcripts

Each are described in this section.

Thematic analysis was used in this study and is a method for identifying themes and patterns within the data in relation to the research questions (Braun & Clarke, 2013). It is one of the most widely used qualitative methods of data analysis. One of the main strengths of thematic analysis is its flexibility to be able to answer any type of research question and analyse any kind of data. There are typically two ways themes can be identified; either in a data-driven way where themes are based on what comes out of the data, or a more structured way where the researcher uses the data to explore particular theoretical ideas. Some researchers will combine these two approaches in one analysis (Braun & Clarke, 2013). In this study, I conducted the analysis in a data-driven way to allow for a broad range of patterns and themes to be explored. In order to identify themes in the data three different processes were undertaken: memoing, transcribing and coding.

3.5.1 *Memoing*

Memoing is the act of recording reflective notes about what the researcher is learning from the data. For me this involved recording my thinking through note taking, soon after each individual interview, to capture my thoughts, ideas, and reflections while they were fresh in my mind. As suggested by Miles and Huberman (1994), early analysis of data can be beneficial in many ways as it encourages the researcher to think about existing data and generate strategies for collecting new data. This study included early analysis during the data collection phase (Miles & Huberman, 1994). Memoing was a technique used after each individual interview as well as after all Interview 1 were completed and all Interview 2 were completed to capture initial thoughts and possible themes or patterns. Memoing serves to assist the researcher in “making conceptual leaps from raw data to those abstractions that explain research phenomena in the context in which it is examined” (Miles & Huberman, 1994, p. 124). The process of memoing was completed on the same day after each interview allowing for early themes to be identified. When all Interview 1 were completed, memoing was used to look for patterns emerging. Memoing was completed again after all Interview 2 were finished. I made a list of points related to each of the questions asked. These points were ideas that stood out from the interviews that potentially could relate to the research questions (see Figure 3).

Figure 3

Examples of Memoing From One Individual Interview

Changes:

Recorded lessons first time round—with levelled attachments and students could choose where they were at. Second time round as many could not identify the right level. So only set one chosen task for each student (out of 3).

Spread was noticeable (easily change in the class—change the task to suit on the spot—hard to do online—so planned so many lessons and then hope you gave the right one to the right student. 3 tasks in the classroom—5 online. Don't want to use excuse—too hard and just not do anything.

Highlight:

Maths via recorded videos—live at 12.30 on google meets for drop ins. No one to start with (fractions topic) but over time kids needed help and parents were contacting saying it was hard and Lisa said I am there at 11.30 each day.

When students were able to record themselves talking through their strategies—giving feedback on this and then the students commenting again.

Surprised:

Natalie—fly under radar—pre test shows areas to work on, not in extension group—had help at home from brother, trying orange and red tasks and reflecting that it was hard but enjoyed it. Again, more time to work on it at home, get help etc. How we can keep stretching her back in the classroom?

I recorded my thoughts and ideas in a journal under these basic headings that related to the interview question that was asked. For example, *highlights* relates to Interview 1, question one: *When thinking about mathematics, what has been one of the biggest highlights for you in remote learning?* Through the memoing process themes begun emerging from the data and these themes formed the basis of the subsequent coding process.

3.5.2 *Transcribing*

Transcription of the recorded interviews was an important part of the data handling and analysis as during transcription fine details and subtleties in the data are examined. It may seem a simple part of the process to listen to short sections of audio and convert them to text. However, it is quite time consuming (Braun & Clarke, 2013). I followed the advice of

these authors and played short snippets of the audio using headphones and my laptop. I was able to stop and start the audio to focus closely on specific sections at a time. My aim was to transcribe what I heard in the recording word for word. After each transcript was finished, I checked it through from start to finish to check for any errors as was recommended. During this process I watched the video recording of each of the interviews, so I could watch what was happening during the interviews as well as listen to what was being said and check it against what I had transcribed. Through this process I watched for facial expressions, gestures, and other non-verbal communications. If there was anything I noticed that I thought was important to the interview I made a note of it on the transcript. For example, a change in facial expression or tone of voice when telling a story about a specific student.

All fourteen interviews were transcribed (see Appendix E). The transcription process started soon after all fourteen interviews were complete. To de-identify participants as well as other people mentioned in the data pseudonyms were used. In the transcripts "Q" was used to record when the researcher was talking, and "A" was used to record when the participant was speaking. Timecodes have also been used to show when in the audio questions were asked by the researcher (see Figure 4).

Figure 4

Timecodes Used in Interviews

05:00

Q: Well, what was one of the biggest highlights for you, in terms of thinking about maths, what was one of the biggest highlights for you in remote learning?

A: I think, one of the biggest things that I loved from it was getting to hear, like the kids were able to record themselves talking through their strategies and things like that, so it was really great to hear. Some of them were really reflective in the strategies they used, and you could – they weren't afraid to really go into detail and they'd record something for like, a minute and a half of them just telling you about what they did, and then you could comment back to them, and then they could answer you again, so that was a real highlight for me being able to sort of challenge them, and then they could come back to you.

Q: Was that through See-Saw?

A: Yeah

Using timecodes for each question has allowed me to find particular sections of interview data quickly and easily, not only in the transcripts but also in the audio and video files.

A transcript of audio should be considered a representation as it is two steps removed from the actual interview experience. Throughout the transcribing process

information could be lost or changed in some way. For example, there were physical losses via interruptions in the data collection in this study because interviews were conducted online. There were small sections in some interviews where internet connection caused short dropouts where words were inaudible. In the transcriptions of the interview's brackets were used to reflect these breaks in recordings with an explanation for the missing transcript, for example "(recording dropping out)" or "(background noise)". Laughing, coughing or other noises from speakers were not recorded in the transcripts. Any non-verbal utterances were also omitted, for example "er" or "umm". These were considered unimportant and unnecessary to the analysis.

3.5.3 *Coding*

Coding is the process of identifying aspects of the data that relate to the research questions. There are two main approaches to coding qualitative data: *selective coding* and *complete coding* (Braun & Clarke, 2013). The purpose of selective coding is data reduction. Instances of the phenomenon the researcher is interested in are selected out of the data. Collections of data are then gathered together as a certain type. Complete coding is where the researcher identifies anything and everything from the data that possibly relates to the research question (Braun & Clarke, 2013). When complete coding, all the data relevant to the project is coded and later in the analysis coding becomes more selective. Coding was used in this project to analyse the data collected from interviews. The process started with complete coding to code all the data relevant to the research questions. In the process of complete coding, codes identify and provide a label for a feature of the data that is relevant to answering the research question. A code can be one word or a short phrase that captures why that specific part of data might be useful (Braun & Clarke, 2013).

Figure 5 is an example in which four examples of codes illustrate a selected category labelled *student engagement*. The *Glossary of Education Reform* defines student engagement as "the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education" (Great Schools Partnership, 2016., para. 1). These were data from four different interviews where the participant mentioned the engagement levels of the students in their class. While reading the interviews, I noticed that these were important pieces of information which may be helpful later in addressing the research question. Using NVivo software the section of text is highlighted and dragged into the "codes" section to be added to an existing code or create a new one.

Figure 5

Code Examples—Student Engagement

Reference 1 - 0.49% Coverage

Our engagement sits roughly at about 40-50%, but we looked at it and went, well, it's 40 to 50% with our recorded videos and our tasks that we were setting, so it's the same for-

Reference 3 - 0.88% Coverage

really engaged with the tasks, nearly all the students; I had a couple who have some wellbeing personal issues with social economic status and that goes back to more family issues,

Reference 2 - 0.24% Coverage

Out of the 20 we probably had 14 I would say regular, consistent, and then we have 3, 70-80%.

Reference 1 - 0.35% Coverage

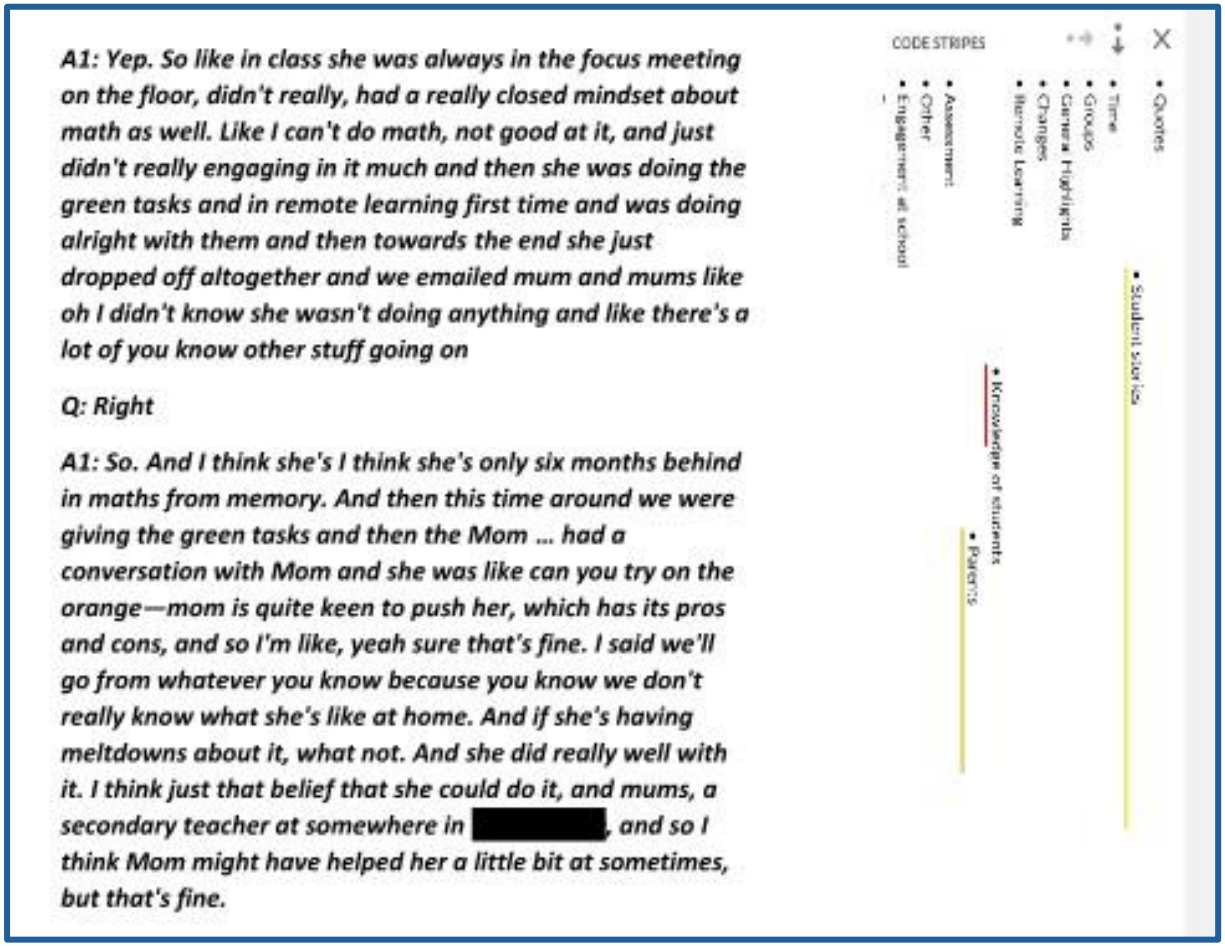
and we really had a focus on student engagement was the top of our line

In qualitative research any one piece of data can be coded in as many different ways as fits the purpose. For example, in Figure 6 we can see that this one section of data from an interview conducted in Interview 1 has been coded three different ways.

Figure 6 is a section of transcript from one of the interviews. For each interview uploaded in NVivo, you can turn the "coding stripes" on which you can see here on the side of the transcript. These "stripes" show the parts of the text that have been assigned to that particular code. In this example, the participant was sharing a story about a particular student in their class. Within this one story many words and phrases were identified as being important and have been coded under three different headings: *student stories*, *knowledge of students*, and *parents*.

Figure 6

Multiple Codes



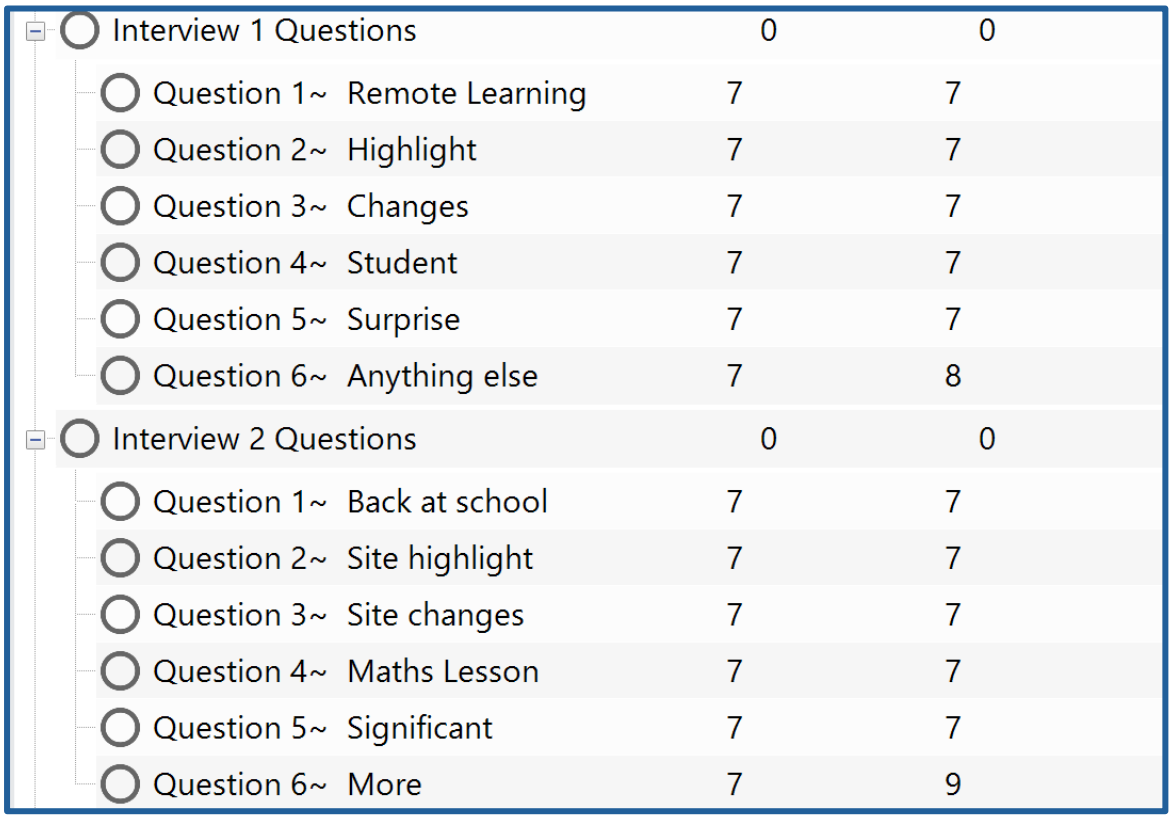
Researchers can choose to do coding by hand using hard-copy data, writing down the code name and marking the text associated in some way. This can also be done digitally using an online program or software such as Microsoft Word or Excel (Braun & Clarke, 2013). Specialised computer software can also be used which was what was chosen in this study. A qualitative data analysis software called NVivo was used. It allows the user to store, organise and analyse unstructured data where deep levels of analyses are required. NVivo can be used to classify, sort, and arrange information to examine relationships in the data. Having a program such as NVivo allows the researcher to work more effectively and conduct deeper analysis. Data can be uploaded, queries can be run, and complex questions asked of the coded data to identify themes and draw conclusions. Because a specialised software was used, themes were able to be generated and collated during the coding process (Braun & Clarke, 2013). Braun and Clarke (2013) describe the coding process as organic and evolving. Researchers begin to understand the shape and texture more and will modify existing codes to incorporate emerging themes and ideas.

In this study, fourteen interviews were uploaded to NVivo and the first step, was to organise the data so that each interview question from Interview 1 and Interview 2 was put

under its own code (see Figure 7). This allows for easier analysis later on when focused on a particular interview question or crossing referencing with similar questions from each interview. It is important to remember that NVivo, like other similar computer programs, cannot do the analysis but rather just offer a tool to assist with the analysis (Braun & Clarke, 2013).

Figure 7

Interview Questions as Separate Codes



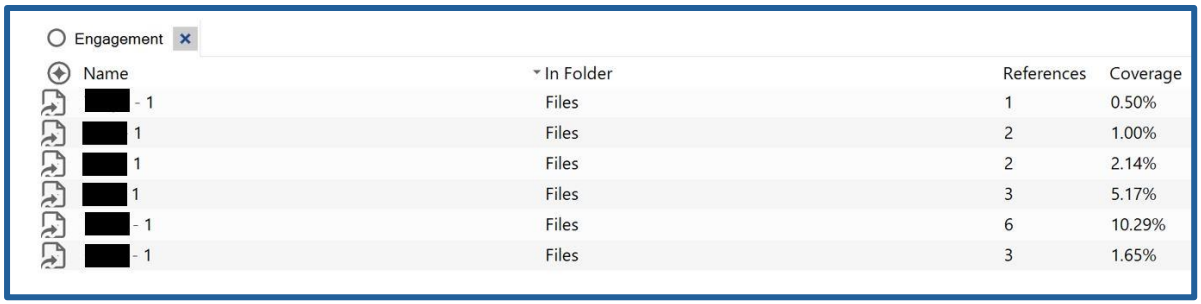
The next step was to identify sections of interviews to remain “uncoded”. These are sections of the interview where conversation does not relate to the research questions and does not need to be included. For each interview transcript these sections are highlighted in grey and filed under a code called “uncoded”.

Then the complete coding process began, and each interview was coded from beginning to end. Words and phrases were searched that followed particular themes that informed the study’s research questions. If there was a section of transcript that I thought was important I highlighted that section and “dragged it” into the coding section to create a new code. As I continued coding each of the interviews more extracts were added to particular codes and more codes were created. This resulted in multiple codes per extract. As noted in Figure 6, an extract could be dragged into more than one code.

In Figure 8 an example of one code is presented as a summary of the frequency of references made to *Engagement* throughout the data for Interview 1 transcripts.

Figure 8

Example of References to Codes—Engagement

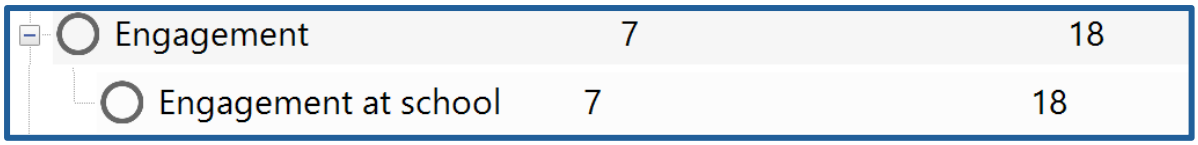


There are seventeen references to “student engagement” throughout the seven interviews conducted in the first round of interviews. In this section of NVivo I can clearly see which interviews I can find these references in and how many references there are per interview.

More references to student engagement were found when coding the data from Interview 2. However, it was decided that these were slightly different references to engagement as participants were referring to the student’s engagement when back in the classroom as opposed to when they were ERT. You can see in Figure 9 how the different references to engagement have been sorted. After Interview 2 was coded, there were eighteen more references to engagement that had been added under the code “Engagement at school”.

Figure 9

Different Engagement Codes



The final stages of the complete coding process involved collating the coded data. As I used specialised software in the form of NVivo this process was able to occur alongside the complete coding process. Similar codes were clustered together under one idea or theme. For example, Figure 10 shows an example of codes that were collated together under the heading *Behaviours*.

Figure 10

Example of Codes Collated—Behaviours

Independent Learners

A2: Was that like those kids that you see that are really good learners and independent learners that actually ask for help and they read your feedback you've got the time to sort of spend with them, conversing with me, whether it's via email or like some of them would be happy to jump on a zoom, and you'd be able to give that one on one attention. I think because they felt like, you know, they were only talking to you, whereas when you're in that whole classroom environment, they may not be as likely to come up and ask you for that help. Or yeah. Especially after you've already finished the lesson. Like where. Yeah. If you could come back and revisit it.

Independent Learners

A1: think it is, though it's the you know. Remote learning generally suits the high flyers like 'cause they've got the independence skills they've got probably better reading skills, but it's like those disadvantage kids. You know that unfortunately.

Seeking feedback

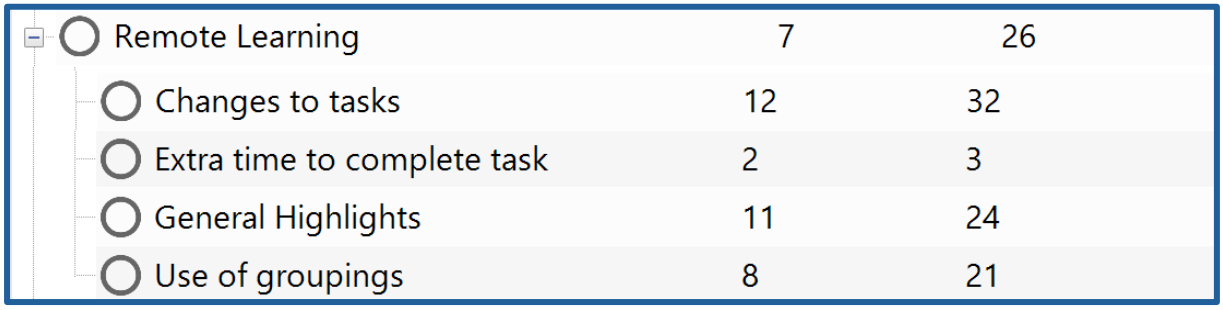
A2: We noticed it because of the behaviours they were showing. They would actively email you all the time, whereas other kids might just sit back or have a go, but they don't really care that much. But these kids would ask all the clarifying questions and they'd write back about their feedback and things like that.

Throughout the interviews there were times when one of the participants would refer to a particular behaviour one or many of their students had demonstrated. These behaviours included independence, confidence, and general good learner behaviours, for example, seeking feedback.

As the complete coding process continued existing codes were modified to incorporate emerging themes and ideas. One way this was done was through creating a hierarchy of codes as different themes as ideas develop. To do this, particular codes (called "child codes" in NVivo) were dragged and dropped into other codes creating themes (called "parent" codes in NVivo). See for example, Figure 11 where several child codes: Changes, General Highlights, Groups and Time, were grouped under the parent code: Remote Learning.

Figure 11

Parent and Child Codes



Remote Learning	7	26
Changes to tasks	12	32
Extra time to complete task	2	3
General Highlights	11	24
Use of groupings	8	21

The first column you can see refers to the number of transcripts including these codes and the second column refers to the number of references in total.

It is important to note that half-way through the complete coding process, I made the decision to go back and manually code the data (Saldaña, 2016). After reading about the benefits and being concerned that I might be missing important information, I wanted to try manual coding to see if any new codes emerged. This approach not only allowed me to identify new codes but also identify new sections of data for codes already created. This new information was then added into NVivo, where the coding process continued.

Once the initial complete coding process was finished for all fourteen interviews (Interview 1 and Interview 2), the analysis continued with several levels of coding being completed as themes began to emerge. Selective coding refers to identifying "instances" of the phenomenon you are studying (Braun & Clarke, 2013) and is an important part of the data analysis. In this step, some instances may be rejected as no longer relevant, and other data may need to be fully developed in order to complete the analysis process. Selective coding was used to revisit the data with a focus on the themes identified. By working through several levels of coding, I ensured my thorough knowledge of and familiarisation with the data.

Three main themes emerged after several levels of coding: Adaptions to mathematical instruction: Teacher responsiveness, Student participation and dispositions, and Communication with families.

The next phase of analysis involved interpreting the data. Using the two noticing frameworks guiding this study, Van Es and Sherin's (2002) *Learning to Notice* framework and Jacobs et al.'s (2010) *Professional Noticing of Children's Mathematical Thinking,* I interpreted the data within the identified themes. The goal was to pinpoint instances when participants referred to a noticed moment or shared a response to a noticed moment.

3.6 Trustworthiness of the Research

When discussing field research, it is important to be able to trust the results (Merriam, 2015). For example, a classroom teacher is not going to want to try a new method of teaching without confidence that it will work or have an impact on student learning. As is the case with this research study, there is a level of trustworthiness because there has been some rigour in conducting the study (Merriam, 2015). During the writing of this thesis, extensive reading was conducted of numerous books and research articles in order to fully understand the methods and methodology chosen. Triangulation and multiple sources are often used to improve the validity and trustworthiness of qualitative research (Lapan et al., 2012). This research project had originally planned to conduct observations along with interviews with each participant. Due to the COVID-19 Pandemic classroom constraints, observations were not possible (either because teachers were involved in ERT or because researchers were not allowed onsite to restrict the number of people in schools to minimise the risk of COVID-19). However, changes allowed for two interviews with each participant on two separate occasions (one while learning during ERT and one after returning to the face-to-face classroom). This change of methodology allowed for a fuller story to be gathered as data and some comparisons between the two learning contexts to be made (Braun & Clarke, 2013).

There are various criteria that are needed to evaluate whether the quality of the qualitative research within a project is considered good or bad practice (Braun & Clarke, 2013). It is also important to understand these criteria in order to reflect on your own research practices when writing up and disseminating your research. While there are no absolute criteria for deciding whether a piece of qualitative research is good or bad, we can still differentiate between a good and bad study (Braun & Clarke, 2013). The following four criteria credibility, transferability, dependability, and confirmability are discussed to address the trustworthiness of this research study.

3.6.1 *Credibility*

Merriam (2015) stated that qualitative researchers cannot capture an objective reality. However, there are strategies that can be put in place to ensure the results are considered credible. One strategy is to have multiple sources of data. As mentioned, this study conducted two separate interviews with each participant, one while teachers and students were engaged in ERT and the other after returning to the classroom and teaching face-to-face. This method of collecting data was chosen to gain teacher reflections on, and perspectives of two different contexts. The time between interviews allowed participants to review what they said in the first interview and to reflect on the reality of teaching and learning mathematics in the different contexts (ERT and face-to-face).

One strategy I chose to adopt was that of note taking. Notes were written directly after each interview (memoing) which captured particular discussions with my participants as well as any emerging themes or patterns. These initial notes were a great source of data when later compared to the detailed transcripts of each interview. Reviewing these during the coding process was helpful when clustering extracts to create parent codes. Notes were also made regularly throughout each study session which was a great way to capture changes in my thinking. Every time I spent time analysing the data I went over my notes from the previous session and continued to take more notes throughout that session.

As a researcher it is important to understand how the relationship you have with the participant will affect how they engage with you during an interview. I already had a professional working relationship with seven of the eight participants whether this was a previous colleague or through various professional networks. This allowed for more personal questions and information shared before and after the interview. It was hoped that, in this situation, I would be seen as being professional and trustworthy, which would make participating in the research a more comfortable experience. This, combined with the semi-structured nature of the interviews, allowed the participants to tell me their accounts of events in a safe and secure environment.

3.6.2 *Transferability*

Transferability refers to the extent to which the findings of one study can be applied to other situations (Merriam, 2015). Every study or every case could be considered an example of something else. What we learn about a particular situation can possibly be transferred to a similar situation. Merriam (2015) suggested leaving the extent to which one study applies to another situation up to the people in those situations. A person can decide whether the findings they are reading can apply to their situation. The researcher needs to provide enough detail in order to allow the reader to make these decisions. Sometimes, as in this research study, a particular situation can be studied because of its uniqueness. In this study, the ERT context was a special situation that provided the opportunity to explore transferability. There was something that might be learned from a new situation as ERT was experienced by all Victorian primary teachers during the COVID-19 pandemic.

3.6.3 *Dependability*

Dependability resembles reliability according to Lapan et al. (2012). To have research results that are dependable means the researcher has ensured there is consistency in research methods. Korstjens and Moser (2018) suggested the strategy of an audit trail. This means keeping thorough records of the research process and documenting every step from start to finish. This includes (but is not limited to) research meeting notes,

reflective thoughts, research materials used, emerging themes, initial findings, and data management routines. All of these processes were put in place and records were kept throughout the present study to ensure that an auditable trail was maintained.

3.6.4 *Confirmability*

The term confirmability relates to being objective (Lapan et al., 2012). The researcher must stay neutral and conduct his or her study with no personal bias. Interpretation should not be based on personal views or preferences but rather should be grounded in the data. Confirmability also means the degree to which other researchers can confirm this research. The findings need to be clearly defined from the data not from the researchers' thoughts or imagination. Extensive reading in this study has assured strong methods of data collection and analysis. The thorough documentation of the study over time also means complete transparency of the research process.

3.7 Role of the Researcher

As a qualitative researcher, I acknowledge the importance of being self-aware and reflexive about my role in the process of collecting, analysing, and interpreting the data. I also am conscious of the personal views I bring to the study. Reading the practical guidance offered by Korstjens and Moser (2018) highlighted for me the sensitive nature of the role of the researcher. It is important that the findings of the present study are based on the experiences and ideas of the participants and tell their story not mine. The researcher can engage in reflexive practice to examine their own views, assumptions, or biases prior to and while conducting the research. For me, this involved taking reflective notes documenting all thoughts and feelings from day one of this study. These notes have also been helpful to go back and reflect on at different points in the journey.

Data collected were interpreted through the lens of the participants and shaped by their experiences. However, participants stories were also interpreted through the researcher's lens and can be shaped by who they are and their experiences. It can be difficult for a researcher to be completely objective. I have a similar background to all participants with many years of primary teaching experience. I also have a social constructivist view of learning which I believe to be similar to that of many of the participants. I lived the experience of teaching through the pandemic, so I had first-hand knowledge of the situations they were recounting and the awareness to imagine those I had not experienced personally. As mentioned above, note taking and memo writing was a valuable tool for documenting ideas and feelings throughout the data collection and analysis processes. It was a tool which has been used by this researcher to set aside any preconceived ideas that might limit the discovery of new themes or ideas.

3.8 Summary

The aim of this study was to investigate teachers' perspectives of noticing as a key action of informal formative classroom mathematics assessment. In particular, the aim was to identify what teachers' notice that is meaningful to mathematical learning in different contexts. In this chapter, the qualitative research methodology and design of this study to achieve this research aims have been outlined. Methods of data collection and analysis used in this research study have been discussed. Online individual semi-structured interviews (with video recording) were the source of data. Thematic analysis was used to identify themes and patterns within the data. In this chapter, evidence of ethics approval, selection of participants and the consideration of the trustworthiness of the study were also included. In the next chapter, Chapter 4, a detailed account of the findings is presented.

Chapter 4: Findings

The aim of this study was to investigate teachers' perspectives of noticing as a key action of informal formative classroom mathematics assessment. In particular, the aim was to identify what teachers notice that is meaningful to mathematical learning in different contexts. Ways in which the information gained through their observations was used by teachers to enhance student learning was also investigated. In this study three key research questions were addressed:

1. What focuses primary teachers' attention to notice moments meaningful to mathematical learning?

2. How do teachers respond to what they notice?

3. Regarding mathematics learning, how does what teachers notice and respond to in the online context compare to the face-to-face context?

Interviews were conducted to record teachers' recollections of moments when they noticed and responded to students' mathematics learning in two different teaching contexts. In this chapter, the findings from two semi-structured interviews are presented. The interviews were recorded via Zoom, on two separate occasions with eight (8) primary teachers. The first set of interviews occurred when teachers and students were engaged in Emergency Remote Teaching (ERT), also known as remote learning, and the second set of interviews were conducted after teachers had returned to the physical classroom (face-to-face). Thematic analysis was used to analyse the interview data. In this study, the thematic analysis began once the interviews were transcribed and involved several phases of inductive coding. In the first phase, anything from the data possibly related to the research questions was coded creating provisional categories. In subsequent phases, it was noticed that particular codes, words, or phrases were coming up repeatedly, relationships between the codes were identified, and patterns began to emerge from the data. Finally, various codes were grouped as sub-categories under main categories and themes began to emerge. See Chapter 3 for a detailed description of the thematic analysis process used.

Key findings have been identified under three main themes:

- Adaptions to mathematical instruction: Teacher responsiveness
- Student participation and dispositions
- Communication with families

Table 2

Examples of How Themes Were Created

Code	Description	Sub-theme	Theme
“Instead of putting one activity up each day, there was always three activities, a higher, a middle, a lower”	How the teacher planned and implemented mathematics lessons during ERT.	Differentiating the learning during ERT.	Teacher responsiveness
“There’s been a lot of problem-solving based stuff. We’ve been doing a lot of collaborate stuff when we can.”	Providing opportunities for students to work together on mathematics tasks.	Task types in the F2F classroom after ERT.	Teacher responsiveness
“You had come who really thrive in the classroom, or some who were really quiet in the classroom, and then they came out of their shell online.”	The variation in engagement, behaviours and dispositions observed in some student between the online and F2F learning environments.	General engagement online	Student participation and dispositions
“A couple of my kids have developed a lot more confidence in asking for help, which has been great.”	Students demonstrating increased confidence in the F2F classroom since returning after ERT.	Positive learning behaviours (F2F)	Student participation and dispositions
“We had a lot of parents, like lots of parent phone calls trying to support the kids and the parents – got to know the parents-some of the parents really well.”	Increased contact with families during ERT to support students and families.	Connecting with parents online during ERT.	Communication with families
“I contacted a couple of parents and said, ‘Look, I am doing this for them’” (providing extension)	Making contact with families about classroom learning after ERT.	Connecting with parents in the F2F classroom after ERT.	Communication with families

Table 2 provides examples illustrating the development of the identified themes. For each theme, two specific codes are presented, along with the sub-theme these codes were categorised under and the resulting theme that emerged from these sub-themes. Additional details about the coding process can be found in Section 3.5.3.

These themes will be discussed in detail in this chapter. Each main theme is reported for two contexts, the online environment (during ERT) and the face-to-face classroom (after ERT). The findings reported for each context reflect the themes as they emerged from the data. Quotes from the interview transcripts have been included to provide excerpts of evidence from the teacher participants. These anecdotes provide an illustration of specific aspects of the findings.

In each of the three main themes, the online (ERT) sub-theme is presented first, followed by those from the face-to-face classroom. The choice was made to present the two different contexts in this order as this was the order in which the data were collected. Logically a “baseline” of data would be collected from a face-to-face classroom situation, and the variation of practice during ERT would be documented. However, the reality of the current study meant there was no data collection before entering ERT, which means it cannot be determined whether the face-to-face data collected after ERT is representative of the face-to-face classroom, before ERT.

4.1 Adaptions to Mathematical Instruction: Teacher Responsiveness

Teachers found “seeing” students' mathematical thinking much more difficult online compared to the face-to-face classroom. When we talk about “in the moment” instructional decision-making in mathematics, we make particular emphasis to decision-making where students' thinking is central (Jacobs et al., 2010). These authors found that creating lessons that build on student's thinking has proven challenging and participants in this study found this even more difficult in ERT. The participants reported their first action as making changes to how they planned and implemented their lessons online compared with the face-to-face classroom environment. This change to planning and teaching created moments for noticing and responding to students' learning in the online environment.

4.1.1 *Teachers’ Reflections on the Online Context*

When entering the first round of ERT, the participants were expected to provide a minimum of one reading, one writing and one mathematics task per day. All participants alluded to two "stages" of ERT. Examples were shared of mathematics lessons from the beginning of their ERT journey, or "stage 1", that included using pre-recorded lessons,

YouTube clips or videos from websites such as Khan Academy. However, students seemed disconnected from this style of learning. Jennifer reported getting feedback from parents and the principal that students seemed to feel that the mathematics was impersonal, "The students were not as engaged and connected because it wasn't us explaining it" [Jennifer, Interview 1]. This led to searching for alternative teaching approaches.

In “stage 2” all participants described changing their lessons to what they called “live” lessons. This referred to synchronous lessons where students were online at a set time each day to complete a task, or part of a task, together with the teacher. For some participants, this was having the whole class online simultaneously, and for others, it was small focus groups, with each group having their own set time. These synchronous lessons aimed to “continue as much as we do in the classroom but in a remote setting” [Greg, Interview 1]. Andrew reflected that the synchronous lessons were “a lot more effective”. He also said that one highlight throughout the time in ERT was: “when you had those groups of students, and you had those interactive sessions going, and you could see them actually getting something from it and actually like they were almost in the classroom” [Andrew, Interview 1]. In this remark it was noted that the actions and reactions of the students were noticed and allowed Greg to compare the students’ learning in the classroom. Sarah commented that “They (the synchronous lessons) are 500 times better, and the workload's so much better, the satisfaction of them is so much better", and Lisa said they were a "real buzz". She explained, "It just feels like you are teaching again”. These two comments revealed the emotional connection to the students the teachers felt when they noticed mathematics lessons going well. The aim here was clearly to create lessons that mimicked the classroom environment and make it easier for teachers to “see” what the students were doing. "Yeah, I think that had the greatest impact. The live sessions you did have with them" [Paul, Interview 1]. The implementation of synchronous lessons in “stage 2” of ERT enabled more opportunities for the teachers to observe students' thinking.

In his first interview, Paul said, **“**You could ask them the questions, and you could almost see what they were doing, even if you could only see a bit of paper in front of you." In the first stage of ERT, all the teachers could see was what was being submitted at the end of the day. Although the teachers could see the work samples and what they were able to complete from the task, they reported missing not being able to observe the students working, notice their thinking, or ask them questions in the moment.

4.1.1.1 Differentiation in the Online Environment.

Differentiation can be defined as: “adapting instruction for weaker students and providing opportunities for acceleration for stronger students.” (Deunk et al., 2018, p. 32)

All participants reported using small group sessions online where students were grouped according to their achievement level, even if this was not a standard teaching practice for them in the physical classroom environment. The participants found that more than just one lesson/task was needed in the online environment for all students to access the learning. They felt that small learning groups were necessary in the online environment to differentiate effectively. Andrew stated,

> So, you are differentiating it [mathematics], of course, but if you did notice you are missing the mark slightly, you could easily adjust that in the classroom, but remote learning, you couldn't, and that was one of the challenges that we had that we then had so many different lessons lined up. [Andrew, Interview 1]

The participants felt they needed to adjust how they planned to suit the online environment. Five teachers noted using three different groups: “Instead of putting up one activity each day, there were always three activities, a higher, a middle, a lower” [Kate, Interview 1]; “We set like a green task which was the lows, orange which was at and then red” [Belinda, Interview 1]; and “We have three maths groups; blue, green, and yellow, blue was the high group” [Jennifer, Interview 1]. Two participants reported using five or more groups pitched at different levels of achievement.

Andrew felt that having a wider range of activities “spread them out a lot more". He noted, "we really had to have more tasks aligned up for each student" [Andrew, Interview 1]. These different ability groups/tasks provided a greater range for teachers to choose from for each student. The teachers were using their prior knowledge of students to decide which level each student should be working on. However, at times there was some uncertainty around which was the right task for a particular student: "Where you can do this one over here, and we're trying to sort of pinpoint, and I think you can do this, but I'm not too sure" [Andrew, Interview 1]. In the classroom, if a student appears to be struggling with a task or finding it too easy, teachers can adjust the task in the moment to ensure it is at the right challenge level for the student. As the participants felt it was not possible to do this online as they could not directly observe students’ reactions to the tasks, they created a range of different activities to ensure every student was completing a task that was appropriate for them.

There were instances when teachers felt the online groups allowed them to challenge a student more than they might have in the face-to-face classroom. For example, Belinda

said, "I feel like I was able to stretch some of those that probably you wouldn't have necessarily given those red tasks [more challenging tasks] to in the classroom" [Interview 1]. Belinda felt that there was not enough time or space to do this in the classroom. At home students had time to complete more than one task and move on to more challenging tasks.

Belinda and Narelle, who shared a grade, reported working with a student who completed a different level task than the one they had initially planned for her:

> In class, she was always in the focus meeting on the floor, and she had a really closed mindset about math as well. Like I can't do math, not good at it, and just didn't really engage in it much… we were giving the green tasks and then the Mum… I had a conversation with Mum, and she was like can you try on the orange - Mum is quite keen to push her, which has its pros and cons, and so I'm like, yeah sure that's fine. I said we'll go from whatever you know because … we don't really know what she's like at home. [Belinda and Narelle, Interview 1]

This was an example of how the teachers were using the parents as their "eyes and ears" to know how the students were going with the tasks they set. Belinda and Narelle went on to say:

> And she actually grasped it all. Her test she got it all right, she did a really good job with it. And I think not being able to see what everyone else is doing and that you know these kids are finished before me or that you know I can't get the help right now when I need it. And then I'm stuck, and I think you know. Right, her being about to choose what time of day she started really helped her as well. [Belinda and Narelle, Interview 1]

With the help of this students' mother, Belinda and Narelle were able to create a plan that allowed Bella to be further challenged in her learning. With the assurance of available support when needed, she was able to complete more challenging tasks successfully.

Belinda and Narelle also shared a story of another student who was given more than one task to choose from: "I think she's had a bit of support at home with one of her brothers…. so I've been giving her the orange task, and the red task and she's been doing all of it." This was an example of how the student was also able to differentiate for themselves and lead their own learning. When she was given the choice of two tasks, she chose to complete both.

> In her reflection, she's like this was hard, but you know, I think I got it in the end and like just how persistent she's been with it… I think they're taking her a long time, but she's done really well, and I probably wouldn't have seen that in the classroom.

> Because you know, she would have just been doing what everyone else is doing in because, so she was such an independent learner. She did the orange task and learned that, but then she had the extra time in the day to be added to the red task and ask for help. And you know. So, she kind of had the time and space that she wouldn't have had. Yeah, I think it'll be interesting to see how she goes when she gets back. About how we can keep stretching her with that. [Belinda and Narelle, Interview 1]

Jennifer also shared a story where a student was offered more than one levelled task. This particular student was another who was considered a "high student in mathematics" who was struggling with her group's tasks online. She found it quite stressful and was reported to have “shut down” without the collaboration of her peers. After discussions with her mother, it was decided that she would have the option of her group's task and the one below if she was finding it too difficult, and she would be attending some one-on-one sessions to help her reconnect with the learning. Jennifer said, “I think she needed that kind of safety net to know it’s okay if I don’t know this really hard stuff, I can try this instead”, and also mentioned that “she still challenged herself anyway, later”. Having multiple levels of mathematics tasks available allowed students to choose their entry level for the mathematical content and then extend themselves if they felt confident to do so.

Greg ran group sessions he called "master classes". Greg explained that these "master classes" were about getting small groups of students together and “try to mimic and copy that classroom small group work”. He went on to say these groups aimed to "get the kids to think well I'm a part of this group to master that part of maths".

For all the participants, differentiation in the online environment looked different from their face-to-face classroom practice. The participants' stories of their students were examples of how they noticed and responded to students in this differentiated online teaching environment by creating tasks addressing a range of mathematical thinking, offering student choice, and conducting online “drop-in” sessions.

4.1.1.1.1 “Drop-in” Sessions. Drop-in sessions were another way two out of eight teachers mentioned differentiating mathematics learning. This was a scheduled time that the teacher would be available "live" online for students to come and ask questions and get help with their mathematics tasks. Creating these “drop-in” sessions was another teacher action in response to those who may be having difficulty completing their tasks independently, needed interaction or support, or those students looking for an extra challenge.

> We came up with, and we put in at 12:30 a drop-in class, which was for 15 minutes. So, any kids that hadn’t understood or needed help they came in. It was open to

> whoever wanted to come along, and it was just if they had any questions about anything that we'd done. Some initially just wanted to come along for a chat. [Kate, Interview 1]

Lisa made a couple of references to her group sessions: "I said, well, I'm sitting there at 11:30. And so, over time, I ended up getting a group of between 8 and 10 of them" [Interview 1]. When parents made contact to say that their child was having difficulty with a particular concept, Lisa would explain that she was available at this time to provide assistance. Lisa also highlighted the case of Millie, who *hated maths* and was very reluctant to come to the drop-in sessions. However, she surprised Lisa by attending daily and actively participating. “She was open to, well, I don’t know, so I’m going to come to the group session and then she was … one of the ones who would actually share her ideas the quickest” [Interview 1]. This experience helped Millie realise the value of asking for assistance.

Although it took a while for students to take up the drop-in opportunities there were clear benefits from attending these sessions. These sessions not only created opportunities for teachers to notice, listen, and respond to students’ mathematical thinking, they gave students personalised learning opportunities in mathematics where they could communicate their thinking to a responsive and supportive teacher.

4.1.1.2 Types of Tasks Implemented Online. As teachers entered ERT, previously planned classroom lessons were being adapted to try to suit the online environment. These changes included the mathematical content being taught, how the lessons were structured, and how the students would complete the tasks. Many hands-on, classroom-based lessons were difficult to adapt to online teaching without the mathematical equipment the students might need. Two participants referred to the type of tasks they set for their students online describing the mathematics content and how it was delivered in the online environment. For example, Belinda commented: "And I think it was the content too. Like last time we taught money, which was quite easy to do online, and we sort of chose the easy topics that the kids would be able to pick up" [Interview 1]. Belinda's comment answered the question, "Have you made any changes to your tasks or the way you deliver them, or the way you teach based on what you have observed of the students along the way?" Initially, in the online environment, teachers attempted to select concepts they considered more manageable for online learning. However, by the second stage of ERT they found themselves unable to continue with this approach. They needed to teach concepts aligned with their schools’ yearly plans and teach content that had not yet been taught.

> And this time, we didn't have that option. We taught multiplication online. Which you know, there was a lot in it and a lot of recording of videos and a lot of recording of the

answers and I think the time and effort we put into making them paid off because a lot of the kids got it. [Belinda, Interview 1]

Despite Belinda's initial concerns about the challenges of teaching multiplication online, she and her team dedicated themselves to utilising digital media. They created videos to mimic the in-person classroom physically modelling multiplication concepts, aiming to assist students in developing their understanding in the online environment. Belinda's observations and analysis of the students' work samples, demonstrated to her that they had successfully understood the concept.

In Belinda and Narelle's shared class arrangement, Narelle taught the Measurement, Geometry, and Statistics and Probability strands with their class. Narelle commented: "I've found that it's a lot drier than it usually is because it's online." She said,

> I do look forward to being able to do some of that… actual teaching hands-on. And I mean, you could still get them to draw things and stuff like that, but you couldn't really do it as fun because they haven't got all the equipment and stuff like that. [Narelle, Interview 1]

Narelle was missing being more hands-on and using concrete materials in the physical classroom and she noticed that the limited materials also limited students' enthusiasm. Greg had similar concerns: "We do a lot of rich tasks and hands-on and project-based maths, and with remote learning, they struggled to see as much of the maths because they just wanted to make and create more" [Interview 1]. Greg's teaching style matched his school's teaching philosophy which was inquiry-based. He was noticing that it was difficult to deepen students' mathematical thinking using the inquiry-based approach in the online environment. Thinking about returning to the physical classroom, Greg said,

> I have found it [mathematical thinking] was much harder to teach, and it was something I've sort of put into the plan going back to onsite [learning], which I think they need a lot more, maybe more visual, more blocks and creating and actually drawing it [the mathematics] out and looking at it. [Greg, Interview 1]

He discussed the challenges he faced while teaching division online, noting that even in his "masterclasses", students struggled to grasp the concept. Greg reflected that the difficulty may be because it was a relatively new concept to these students, lacking sufficient prior knowledge and hands-on materials to manipulate. He considered how he would address this on return to the face-to-face classroom and immerse the students into the mathematics content, "In the classroom, it's really easy to do because you can just use examples of other students, and you can get someone to say, oh look, we can see some

angles in here or we can see some measurement." Greg noticed that the opportunities he could generate for explanation and discussion between students were not available online. He could not capitalise on spontaneous mathematical reasoning to build classroom discourse as was possible in the classroom. This is something he is comfortable and confident doing in the physical classroom.

4.1.1.3 Missing "Acting in the Moment" Opportunities. Teachers spend part of every mathematics lesson, circulating and engaging with their students (Jacobs & Empson, 2016). During this time, teachers would often notice particular moments and decide how best to act in these moments. It was this practice that the participants were missing while in ERT. There were fewer opportunities for noticing online. Responses were usually delayed, and teachers were unsure how best to respond.

In the first interview, two participants reflected on their classroom practice, highlighting what they were missing in ERT. Andrew stated: "Because normally, in the classroom, you could see and you could ask them [students] a question; you could say, show me how you're doing this. And you would identify if they've got the concept or not" [Interview 1]. He went on to say,

> in the classroom, you can quickly think on your feet and modify for the student. That's a little bit too easy. I'm going to push you up here. That's a bit too hard. I'm going to bring you back, and you can move things forward and backwards quite easily in the classroom. [Andrew, Interview 1]

In the face-to-face classroom, Andrew found it easier to gauge how well the mathematical content suited each learner. He could observe whether or not the task was appropriate for the students and decide when and how to make necessary adjustments. Greg also reflected on his role in the face-to-face classroom:

> The main point is that they just sometimes need that person over their shoulder just to sort of give them an inquiry question, you know, give them say what happens if you do this or maybe think about that – they didn't get that. [Greg, Interview 1]

Participants noticed the absence of the "in the moment" decision making opportunities that were available in the face-to-face classroom by observing and using the mathematical actions and interactions of the students. In the online environment, teachers used synchronous lessons to try and gain more opportunities to notice and act.

Narelle reported how she responded to what she noticed online:

> I could meet with them the following morning to go through what they didn't understand and to help them then with the task that was on the following day. Like, I guess in the classroom you help them as you're going, but I actually had the time to be able to have them sort of as a focus group. [Narelle, Interview 1]

In the face-to-face classroom, Narelle would generally be able to assist any students that were stuck as they were working through a task. Although this was not possible online, Narelle found she could check in with the class in their morning meeting and ask how they went with the previous day's task. If any students had found it difficult, she could offer to stay with them after the meeting to go through the task together in a small group.

4.1.1.4 Providing Student Feedback Online. Giving feedback to students is part of a teacher's daily practice. Feedback refers to “a broad range of teachers’ interactions with students in which the teacher provides some information back to the student about their performance or effort” (Pianta et al., 2012) This posed challenges in the online environment, as reported by the participants.

In the online environment, the feedback was mostly in written form, either on tasks submitted, on the school's chosen platform (for example, Google Classroom) or via email. However, Jennifer did report choosing to give her feedback via audio recordings:

> It was teacher choice, but I preferred to do all my comments verbally because then it felt like they were more inclined to act, and then they often either wrote me something back or recorded their voice back to answer, you know, the additional prompt. [Jennifer, Interview 1]

Jennifer was using a platform called *See-Saw*. It allowed the students to audio record their answers to tasks and send them to their teacher. Jennifer noticed that many of her students liked this function and were quite reflective in discussing the strategies they used to solve a task. Jennifer then recorded her feedback verbally to the students as it felt more like they were conversing. As a result, she could prompt or ask another question, and students were more likely to respond again.

Narelle and Belinda discussed their feedback practices online for their students: "They read your feedback, and you've got the time to sort of spend with them" [Narelle, Interview 1]. Narelle was referring to students in their class who were happy to communicate with them via email or would be willing to jump on a Zoom meeting, and then they could give these students one-on-one attention. Belinda added that this created opportunities for them

to "stretch" some of those they may not have been able to in the classroom. She was able to give them more complex tasks to try and extend their thinking.

The expectation from Narelle and Belinda's school was that they provided detailed feedback on one piece of work per day. However, they found it was more complex than this, as students may have needed more feedback on a particular piece of work: "It's all very well to say this is the one task we're going to mark properly today and give feedback on, but it just…" [Belinda, Interview 1], "Especially when they make mistakes and things like that, you need to [give feedback]" [Narelle, Interview 1].

Narelle found it difficult not to give feedback when she saw that a student had made a mistake or seemed to be struggling with a task. She wanted to act on what she had noticed and help the student by providing them with some feedback that would assist them in moving forward.

Jennifer's school had the same expectations. However, Jennifer had the same concern as Narelle and could not ignore issues if they arose:

> We were told we only had to comment on one thing each day, which was really generous, but we didn't, because we did, probably, commented on, I would say… 75 percent of things, just because like if you see a child got it wrong, you're not going to ignore it. [Jennifer, Interview 1]

Jennifer went on to say: "You need to correct the misconceptions. And also, if you've got a student who is disengaged, you want to keep pumping them up" [Jennifer, Interview 1]. Jennifer aimed not only to assist students struggling with a task but also to acknowledge and celebrate those students who had exceeded expectations. In reference to a specific student she stated, "I shared his work with everyone. That was something to celebrate" [Jennifer, Interview 1]. Jennifer's comment referred to a student who had completed his task on money and then extended the learning by converting money into different global currencies. Impressed by his effort, Jennifer wanted to showcase and celebrate his wonderful work.

Lisa also shared instances of celebrating student work online, "And so, I've dropped off a certificate at his house every week" [Lisa, Interview 1]. This student was working in Lisa's weekly mathematics extension group. Each lesson, she would leave the group with an extra task if they wanted to complete it in their own time before the next lesson, and every week he completed the task. Lisa wanted to keep encouraging and motivating him by celebrating his work. Sharing students work and providing positive feedback was easier in the face-to-face classroom.

Lisa commented that she found giving feedback online difficult in her situation, "To begin with, it's harder to give feedback because I don't know if I—if that's your best, you know, I don't know" [Lisa, Interview 1]. Having not taught the students before entering ERT, Lisa's situation was different. She felt she did not know the students well enough to know if the work they submitted was their best work or if she should be pushing them further. Lisa noticed that effectively assessing each student's mathematical output relies upon knowing the student's prior "history" mathematically. To take an extreme example, for a student who rarely completed any mathematics, the completion of a problem-solving task may be a huge achievement.

Although it was harder to notice students' mathematical thinking online, participants in this study found ways to create more opportunities for noticing during ERT. However, the participants were still looking forward to the return to the face-to-face classroom, where there were more opportunities for hands-on learning and noticing and responding in the moment.

4.1.2 *Teachers' Reflections on the Face-To-Face Context*

Participants were excited about getting back into the classroom: "I do look forward to being able to do some … actual teaching with hands-on" [Narelle, Interview 1], "I'm going to do a lot of rich tasks back at school and really focus on engagement/creation and putting the mathematics into the rich tasks" [Greg, Interview 1]. Having not taught the students before entering ERT, Lisa was looking forward to teaching her class in the physical classroom environment, "I will definitely be able to take what I've gained from remote. Yeah, back in there (in the physical classroom)" [Lisa, Interview 1]. She mentioned learning about their interests, who was confident and who was not, each student's level of achievement, and who to take out for small groups. She also noted more personal things such as family circumstances or how they came to Australia. She stated, "It's interesting, because I actually think I've learnt things about my students in remote learning that I wouldn't necessarily have otherwise just being in the classroom". Lisa felt that the students may have felt more comfortable to share personal stories through digital communication.

In the next sections of the thesis, matters concerning classroom differentiation of mathematics, task types implemented in the face-to-face classroom, acting in the moment, and providing feedback in the classroom will be examined as findings from the data.

4.1.2.1 Differentiation in the Face-To-Face Classroom. The data shows that the way teachers catered for the range of different mathematical experience and knowledge of the students in their classrooms face-to-face was different from the online context.

All participants had reported using small group sessions online where students were grouped according to their ability, even if this was not a standard teaching practice for them

in the physical classroom environment. However, in the face-to-face classroom participants reported other ways they differentiated. For example,

> In the classroom, I probably do more of that open-ended sort of tasks which are differentiated, but differentiated – not this group got this activity, this group got this activity, some of those tasks we've probably done before where they can take it, they can find one solution to the problem or they can find 20 different ways, and so I probably do more of that within the classroom rather than clear groups. [Sarah, Interview 1]

Sarah reported differentiating the learning in the face-to-face classroom by providing one task with various options for students. These options included multiple possible answers, different materials they could use, and diverse strategies they could implement.

Jennifer and Andrew also stated during their interviews that this was their preferred way to teach in the classroom. In their classrooms, they liked to use open tasks in mathematics and then found other ways to differentiate. For example, Jennifer stated, "Just that little check-in to see what they're doing" [Interview 2]. Jennifer would do quick check-ins with the students to ensure that the students understood the task and that the task was appropriate and at the right level for the individual. Andrew had a similar strategy, "And it's about asking those questions to the kids and getting them to actually show you what they can do" [Interview 2]. Andrew used questioning when implementing problem-solving tasks in the classroom, allowing him to differentiate for individuals and develop a student's mathematical thinking.

In his second interview, Greg said,

> I feel like I'm able to push them to a bit of a high—they put a level they think they're at you know that's where they're sort of at. And I feel at school I've been able to just add that little centimetre to it. Just a touch, I'm not pushing them over the board, but I've just been able to go okay, let's just go a little bit more you know, and they go yeah, I trust you. [Greg, Interview 2]

This answered the question, "What has been a highlight for you in mathematics recently since returning (to the face-to-face classroom)?" Greg later discussed another highlight, "I think being able to develop those bigger ideas in the classroom and attending to those ideas." He felt he was not only able to go deeper with the mathematical content he was teaching in the physical classroom but was also more confident to differentiate and challenge students in the moment. Determining the appropriate level of challenge for students online proved to be difficult. There was a concern that pushing students too hard or

presenting tasks beyond their capabilities, might led to disengagement, and you would lose them in ERT. Greg acknowledged that in the face-to-face classroom assessing students understanding of a concept was more straightforward. He believed there existed a level of trust wherein students would allow him to further challenge them.

Jennifer was the only participant who reported trying to continue the differentiated/levelled groups they had online once back in the classroom. Her team had felt they had managed it well online and wanted to try the same approach when returning to school. However, Jennifer found this did not work for her or her students in the physical classroom:

> The top group were doing BIDMAS [order of operations] at a really advanced level, medium [the medium group]… some of them were ready for BIDMAS and some of them were still doing like input/output stuff, and then the … group was still doing—don't even—I can't remember, but it was not the same. So, we sent the yellow group off to do their thing, and they were like we don't understand. [Jennifer, Interview 2]

Jennifer observed that the different tasks provided to each group were too diverse, posing a challenge when introducing the lesson to the entire class. When employing a whole class focus at the beginning of the lesson, some groups struggled to see the connection between their task and the whole class focus. The students required extensive guidance due to a lack of understanding of their task. Although they had found this style of planning and teaching to be effective in the online environment, it proved less successful in the face-to-face classroom. In ERT students could only see their assigned tasks, but confusion arose due to the variety of tasks that were assigned to different students. Jennifer then elaborated on how she modified these lessons to align with her usual teaching style:

> On one particular task, the yellow groups [task] was so easy that they had it finished in 10 minutes. And then the green groups was so hard that none of them understood, and it was just disastrous. And so, I think I ended up changing everything for that session because the only activity that was a good activity was the blue group, so I kind of adapted that for the other groups. [Jennifer, Interview 2]

In this *Goldilocks* style of planning, Jennifer had found the task that was *just right* and managed to create an open-ended task from this where all of the students in her class could access the learning. Jennifer went on to say: "If you have the one concept and you make it more open-ended and … each kind of level comes with an added layer of understanding, that's all you need" [Jennifer, Interview 2]. Jennifer found she was able to differentiate effectively through one open-ended task for her students by adding different levels of

challenge rather than giving a range of different problems. She found she could adjust the level of challenge through questioning, prompting or just checking in with students.

On the other hand, using just one open-ended, problem-solving style task for the whole class was a new way of teaching. Andrew said, "It's been great seeing the kids now seeing mathematics in a slightly different way since they've been back, a lot more investigation work, so that's been one of the key things, more problem-solving" [Interview 2]. He went on to say,

> It's also been easy to plan, too, because you don't have to plan for all these different types of groups and how to focus which connects with all these different people. You can put a—an investigation up there where they can work in collaborative groups, and—and it can be extended for a lot of different—in so many different ways. [Andrew, Interview 2]

It was clear that Andrew noticed the benefits of this new way of planning and teaching for both him and his students.

4.1.2.2 Task Types Implemented in the Face-To-Face Classroom. Before returning to the physical classroom, participants were planning particular tasks for face-to-face teaching. During his first interview, Greg mentioned, "I'm going to do a lot of rich tasks back at school and really focus on engagement/creation and putting the mathematics into the rich tasks." Narelle said, "I do look forward to being able to do some of that actual teaching, hands on."

Once participants were in classrooms face-to-face, they noticed they had been limited in the types of tasks they were able to provide for their students in the online environment. Narelle commented that a lack of emotional engagement as it did not feel "fun" due to the lack of equipment and resources. Belinda agreed, stating: "And again, you couldn't do something really like that in remote learning [playing whole class maths games] and get the same - atmosphere and the same reaction." [Interview 2]. She noticed the enjoyment of lessons in the face-to-face classroom: "They actually kind of understood it, and they got to play games and had fun. It was kind of nice, whereas sometimes, in remote learning, you couldn't have fun." [Interview 2].

Participants were enjoying being able to create hands-on tasks, play games and make real life links in mathematics:

> We just went on an "angles walk" around the school. Such a simple thing, but they just loved it, and most of them, by the end of that ten-minute walk, remembered what

all the angles were called. Just being able to find them outside and not be in the classroom. [Narelle, Interview 2]

I felt like we've been able to really investigate completely new things they've never seen. So that's probably been the biggest part of being at school at the moment is just yeah investigating things we don't know or a bit more we're curious about. [Greg, Interview 2]

On returning to the classroom, the participants wanted to ensure that they provided students with an exciting learning environment and opportunities for collaborating in inquiry-based lessons: “There’s been lots of problem-solving based stuff. We’ve been doing a lot of collaborative stuff when we can” [Jennifer, Interview 2]. Narelle also noticed that she and her students enjoyed finding moments for incidental teaching and learning: "And we even do mystery objects at the end of the day. Give me an obtuse angle. It's those little … It's those sorts of hits that those kids missed" [Narelle, Interview 2].

Participants described particular inquiry-based lessons they had implemented on return to the classroom. In answer to either "What has been a recent highlight for you in maths?" or "Can you think of a recent maths lesson that was surprising or interesting?" Greg’s example was of a unit where students were asked to design a mini golf course:

So that session I had every student doing measurement and area and the geometry sort of thinking but they’ll all doing something a little bit different … I asked them just to show me your mathematical thinking in your mini golf course. [Greg, Interview 2]

Greg had provided a broad framework for the task giving the students the freedom to choose the areas they wanted to concentrate on, enabling them to follow their interests and their display their strengths.

Participants recounted other examples of lessons or units of mathematical investigation that they had noticed which surprised and interested them. These included making a robot, a Veggie Olympics unit, a Market Day unit where students were asked to create their own stalls and a Lego Shop Day. The Lego Shop was a lesson that Lisa had implemented in her classroom where the students "buy" the Lego pieces they want and build items to sell at their stalls. The aim is to be the team with the largest profit. Lisa stated, “They did just love that Lego experience. We ended up doing it I think for half a day. Just all that thinking and what they would do differently and keeping the budget … it was so good” [Interview 2].

These hands-on, inquiry-based tasks were a highlight for the participants in the face-to-face environment. Not only were the tasks engaging students back into the mathematics

and providing opportunities for collaboration, but they were allowing the teachers more moments to “see” the students’ thinking and notice its depth and detail.

4.1.2.3 Acting “in the Moment”. Being back in the face-to-face classroom, allowed teachers more opportunities to notice and respond to students “in the moment”. The term responsive teaching is conceptualised by Jacobs and Empson (2016) as “a type of teaching in which teachers’ instructional decisions about what to pursue and how to pursue it are continually adjusted during instruction in response to children’s content-specific thinking, instead of being determined in advance” (p.185). In the face-to-face classroom, some teacher actions happen in the moment, and some actions might relate to planning future lessons. However, it was this "in the moment” responding that teachers had missed in the online environment.

Participants appreciated being back in the classroom especially being able to notice and respond to student actions in the moment, opportunities for powerful observational assessment that could be used immediately. Jennifer reported seeing students developing their understanding: “I think maths in particular, I think they’re actually- they’re having all those “ah-ha!” moments like and I think they’re seeing them more” [Sarah, Interview 2]. Other participants had similar reports:

> Just being able to go around and actually see what they’re doing and be able to help them and interact with them one on one, at the [of] time learning, not after the fact was nice. You can see them actually making that progression and making that ah-ha, having ah-ha moments. [Narelle, Interview 2]

> Being able to – even when they were playing Mastermind, I was walking around and going, can you read me your decimal number, whereas you wouldn’t be able to do that remote, get them to actually read it out loud to you. [Belinda, Interview 2]

> The “lows” kind of struggled with how to put it together, but you could model it in that instant. Whereas that was really hard with remote, to try and teach them how to say it and them say it back to you. So that was really nice. [Belinda, Interview 2]

> One of the biggest highlights for me is seeing their faces when kind of the penny drops. Yeah, it's been great to kind of see their thinking and them take on what you're saying after they've asked for help, you've been able to give them some work examples. [Jennifer, Interview 2]

Participants appreciated being able to notice and respond quickly, checking students’ understanding and being able to assist them in real-time. There were reports from some

participants about discussions and questions they were able to ask during learning to elicit students' thinking:

> We had a session where we made play dough. But I took away the cups, so all they had was a quarter of a cup. And so, if it says, okay, you need to put in three quarters of a cup, or one-and-a-half cups of this, what would you have to do? [Andrew, Interview 2]

> I found the cartesian plane – I gave them this thing that was a code and they had to crack it and draw the picture and stuff, and it took them ages because they had to do it properly. I just gave him a sheet and then I said read this, this explains it – and work out amongst yourselves. They loved it, and like the other week when I debriefed with them after, Aaron was like, "We spent 10 minutes on one question talking about it", and I said, "You guys were on task talking for 10 minutes about one question?", and he was like, "yes". "I said that's amazing. I am so happy to hear that". I said, "Really were you guys on task talking about that for 10 minutes." [They said], "Yes, because we were all different on it and we had to get our ideas out." And they just were really thriving off it. [Lisa, Interview 2]

> You know I had one group of girls who bought all this stuff, and they had no money left. And I am like, "Well, what could you do then because you are staying stuck at the moment?"… so I talked to them for a bit, walked away, came back and they were still stuck. And then I said 'Well, you've got some things here for sale … what could you do to entice people?" They were "Okay reduce them", so they reduced [the price of] some of their stock and then they actually started selling stuff, and then they did have enough money to go and buy things in the end, and they were like okay buzzing from okay we did sell some stuff. [Lisa, Interview 2]

By discussing the learning and asking prompting questions in the moment the participants were able to get the students to think more deeply about the task and the mathematics involved in solving it. The participants could then notice what the students did next and act or respond appropriately.

4.1.2.4 Providing Student Feedback in the Face-To-Face Classroom. Most participants did not discuss in detail the feedback they gave students once they returned to the physical classroom. This may have been because they drew on tacit knowledge and returned to their usual practices, which were not considered new or different.

Lisa, who had not taught her students prior to ERT, did share some examples of giving feedback on return to the classroom:

> I did say to him later, “That was really great that you wanted to do that, and you want to challenge yourself. You sat there and you did it and didn’t get up and you weren’t distracted” so it was nice. [Lisa, Interview 2]

> I said to Dean, “Have you learnt something new?” I said, “Was there something today that you didn't know already”, and he is—“yeah”—“Oh are you sure? Because I don't know if there is much that you don't know” and he's—“Yep I know … there was something” and they have just been thriving off it. [Lisa, Interview 2]

Lisa's second comment here not only gave an example of the feedback that she gives students but also valued seeking feedback from the students. Lisa wanted to check in with Declan to ensure that she was providing him with tasks with the right level of challenge.

Responding to the question, "What have you noticed about a particular student recently that was significant or interesting?" Lisa shared a story about a student, Tyson, who was not usually one to challenge himself in mathematics. While monitoring the classroom, Lisa overheard this conversation and noticed that Tyson was looking to challenge himself and had asked to join a small group working on an extension task. He had watched the group leave with their task:

> Tyson he was sort of looking at them, and I heard Chris say to him, why don't you ask her if you can come out? And so, because I heard that I just went up to him and said, “Tyson do you want to go and try it with them today?” And he said, “Yeah okay.” And so, he's been good too. I wasn't quite sure how he would go but it was a nice surprise actually—him wanting to go and challenge himself for a change. [Lisa, Interview 2]

This example illustrates how Lisa noticed the situation then decided to act in the moment and offered this student the opportunity to work with the group completing an extension task.

4.1.3 *Summary*

Participants discussed their practices in the different contexts and the strategies they implemented in order to notice student learning. Reports revealed some differences between the two contexts. It was difficult to notice students’ thinking in the online environment. Findings indicated that participants were looking to reproduce the face-to-face classroom experience as much as possible online. When first entering ERT, the participants thought they were creating good quality lessons that could be used online. However, it became clear that the lack of teacher presence in the mathematics lesson was an issue. The change to

synchronous lessons not only created a space for that teacher presence in the online environment but seemed to create a more “classroom-like” environment overall. It created opportunities for noticing in the moment where teachers could then decide how best to respond.

Returning to the face-to-face classroom allowed the participants to appreciate the value of noticing students’ thinking “in the moment” and addressing students’ immediate learning needs. Participants reported noticing students’ moments of self-discovery. The interactive nature of the face-to-face classroom provided opportunities to informally assess students learning by checking students’ understanding, addressing misconceptions, and providing immediate feedback. Participants also found these moments of noticing student thinking in the face-to-face classroom beneficial for opportunistic teaching and learning.

Adapting practices for differentiation proved to be difficult in the online environment. Participants in this study reported using a range of different levelled tasks online, even if this was different from their regular practice in the physical classroom. Participants reported being able to adjust the level of challenge in the physical classroom in the moment, but this was not possible in the online environment. This led to them to planning a broader range of tasks online in order to give each student a task that was at the appropriate level of challenge.

On return to the face-to-face classroom, the participants reported using a more hands-on, inquiry, problem-solving based approach that they had not been able to reproduce online. Participants returned to using open-ended, rich tasks and appreciated being able to investigate concepts more thoroughly and question students in the moment to foster deeper thinking.

Although it was more challenging to notice students’ thinking in the online environment, the teachers reported adjusting the structure of the learning environment online to foster greater interaction and observe and monitor students’ mathematics learning.

These differences highlight some of the challenges of online learning compared to the face-to-face classroom. A face-to-face classroom is a social environment where students can collaborate and interact with their teachers and peers. Creating opportunities for synchronous lessons online allowed for some interaction; however, participants in this study found it did not reproduce the same level of interaction you would have in the face-to-face classroom.

4.2 Student Participation and Dispositions

In the preceding section, findings were reported regarding the teacher practices implemented by the participants in this study within the two contexts. In this section, the student's responses to learning in the two contexts are discussed with a particular focus on the observed level of student engagement, and their dispositions towards their learning as reported by the participants. Participants commented on how the students' engaged with the learning.

In each interview, before asking the four main questions, participants were asked, "How is remote learning going?" in Interview 1, and "How have the students been since returning from remote learning?" in Interview 2. Teachers first discussed their students' learning dispositions in response to these questions. There was a link between these observed dispositions and how and what the participants noticed about their students' mathematical learning.

Student participation and dispositions emerged from the data analysis as a significant theme in both the online and the face-to-face classroom.

4.2.1 *Teachers' Reflections on the Online Context*

Noticing students' thinking online proved to be a challenge in ERT. When unable to notice students' thinking, participants became more focused on how students engaged in their learning in the online environment. Entering ERT, the participants were unsure how their students would adapt to this new way of learning.

All participants reported noticing changes to students' engagement levels online that differed from what they had expected. Participants drew on their prior knowledge of the students and what they had observed of them in the face-to-face classroom previously (before ERT) and then compared this to what they saw in the online environment.

4.2.1.1 General Engagement Transitioning to ERT. When asked, "What was the level of engagement in your class?" all of the teachers in this study reported that they felt their students were largely engaged in online mathematics learning. Most participants reported numerical values ranging between two-thirds to 80%. The only difference was Sarah, who reported that the engagement of her class sat at around 40-50% online. However, this was the same level of engagement that she would get in the face-to-face

classroom, so she was not expecting the engagement level of her students to be any higher online.

There were descriptions offered as to possible reasons for students' disengagement and strategies teachers used to try and support disengaged students and encourage them to engage in ERT. These data will be discussed later in this chapter.

When the participants first entered ERT, there were reports of issues around engagement, particularly being on camera. Students were being quite shy or reclusive when online. Participants noted students wanting to avoid having cameras on, muting themselves and being reluctant to share or talk online, even if they were not usually shy in the physical classroom.

> You know, the kids will turn the cameras off, and we just sort of sit there, and you know, or they'll be talking to someone in the background… will be making noise and you know it just didn't have the same impact. They turn the cameras off a lot and then they mute themselves and microphone. [Andrew, Interview 1]

In his first interview, Greg shared that he struggled to get "more student voice" in the online environment. He was trying to encourage less teacher voice and more student voice, similar to how his face-to-face classroom would generally be. "You're asking the kids who would like to share, and it's sort of silence, but they're so noisy and engaged in the classroom in groups, but then in a video call setting, they really take a step back." He felt it would just take a bit of getting used to. "I think it's just the video conferencing aspect, I think that it's just they feel they're on camera and they see it as like they're being recorded, and they see it as everybody's watching me." Greg shared a strategy he tried implementing, "I've been asking maybe we could turn our cameras off and then just use the audio function", which he hoped would engage those that might be camera shy. Jennifer reported similar findings saying, "It was really hard, because a lot of them became quite reclusive." She also mentioned, "What we found was that they were quite shy in the WebEx groups, some of them were confident to answer, but majority were very scared, even if they knew the answer, they were too scared to say something." The students were not used to this online environment, and it took some time to adjust and get used to this new way of learning.

All students adapted differently to ERT. Various factors might affect a student's experience with learning online. Participants reported both positive and negative examples of their students' engagement levels online.

4.2.1.2 Examples of Engagement Online. The participants did notice a general increase in engagement in "stage 2" of ERT. In this stage, synchronous lessons were

introduced in which students could participate and interact with their teacher and each other. One of the main reasons for this change was feedback from parents about the level of disengagement from students due to a lack of teacher presence online.

The participants noticed students who were more engaged online than in the face-to-face classroom. Jennifer commented: “Most of them (were engaged). And it's funny you had some were really quiet in the classroom and then came out of their shell online" [Interview 1].

In her first interview, Kate spoke of a very quiet student in the classroom who had only just begun to engage more with her mathematics learning before they entered ERT. Kate was unsure what levels of engagement she would see from this student online. Kate reported,

> With the online learning (ERT), she would be first on, we had a thing each day like house points for the first 3 students on each Webex. But she would be first on, constantly putting her hand up and sharing or asking online, coming to the drop-in class, (and in) everything. [Kate, Interview 1]

Greg spoke of students in his class where the engagement was almost the opposite of what he had seen in the face-to-face classroom up until that point:

> I’ve noticed that with quite a few students who would be the students who would do the bare minimum in the classroom unless they were really prompted and questioned and challenged with their work, their work was at a very high calibre from home. And so, a few of them actually quite shocked me because I hadn’t seen this type of work and effort in the classroom. [Greg, Interview 1]

Sarah, who came from a low SES school with many behaviour concerns in the classroom, said, "I think I've really got to know the kids who are really eager to do stuff that I probably haven't noticed in the classroom as much." These students were generally quiet in the classroom, and when dealing with behaviour issues and the day-to-day running of the classroom. "You don't notice as much that they do want the help or do want to sit there and try". Sarah noticed that these few students were online for every session, who were the ones "who might not have those strategies to solve it themselves, but they were actually wanting the help". These students were actively choosing to turn up every day, giving Sarah time to see these students more one-on-one. "You see it more because you're tracking their engagement, you're tracking which tasks they've completed, you're tracking everything." At Sarah's school, they tracked the engagement carefully. Teachers were asked to contact

families to check on the students' wellbeing if they had not seen or heard from them in more than a few days.

Participants noticed particular students that *thrived* in the online environment. These students seemed much more engaged in the online environment than the face-to-face classroom. Kate shared a story about a student she described as being "not quiet, but not loud" in the face-to-face classroom and a student who could possibly "get lost in the middle". "She has absolutely flourished, just amazingly. The online learning (ERT), I think it has suited her". From speaking to her parents, Kate learned this student had a great set-up at home for learning, an area that her parents had been set up as a school play area with a blackboard, whiteboard, and other school supplies. The student was comfortable in her home set-up and could engage in online learning independently.

When asked, "Can you tell me something you have noticed about a student that was interesting or significant?" Greg spoke of a student who "really enjoyed remote learning." He noticed this student's increased communication. This student would be the last person to ask for help in the face-to-face classroom. He said that he occasionally received an email from her parents letting him know that she had been struggling with the mathematics lesson that day but was too shy or nervous to come and ask for help. In the online environment, the student would contact Greg regularly, saying, "I don't get it, can you help me". To Greg, it "really stood out that she was actually able to communicate her understanding or misunderstanding much better through a text message". During ERT, Greg ran "masterclasses" similar to small focus groups that this student would attend. The student would message Greg and ask if more sessions were running and if she could attend any extra sessions. Greg wondered about the increase in engagement from this student online - "maybe it was just more that she was able to informally contact me, so it was just through a message rather than a call or in face-to-face." As this student was reluctant to ask for help in the classroom it seems she was a shy student or at least reluctant to speak to the teacher in front of her peers. The online environment provided her with a space for more private, digital interpersonal communication with her teacher, of which she was more comfortable.

Andrew found that the ERT experience suited some of his students:

> I think that remote learning for them (some students) helped them where they were just able to work at their own pace. They weren't structured by - maths is for one hour. For them, it was—I'm just going to sit through here and just work through on my own, at my pace. [Andrew, Interview 1].

These are some examples of students "thriving" in the online environment. For some students, it was an environment that worked for them. There were no classroom pressures

or distractions, and you did not have to compare your work to anyone else. Students could set up their own learning space, work to their own time schedules and could find alternative or informal ways to communicate with their teachers and peers.

4.2.1.3 Examples of Disengagement Online. Several comments were made by participants of students who generally engaged well in mathematics in the face-to-face classroom but were not engaging with the tasks in the same way online: “They haven’t even really tried, they're just saying they did it" [Kate, Interview 1]; "And then it gets frustrating when you know students might opt out or not do the activity or you know just rush through it, and you won't do the expectation you would like at school" [Andrew, Interview 1]; and "But then you had capable kids going for the absolute basic, doing it in 5 seconds and not doing anything else" [Kate, Interview 1]. There was clearly a lack of engagement when completing tasks for some students when learning from home.

Participants noticed the students' lack of effort, motivation, and unwillingness to challenge themselves. Most of these comments referred to disengaged students in general but related to students that were expected to do better (or more) online based on what teachers had observed of them in the face-to-face classroom. It was difficult for participants to know what action to take without knowing why these students were not engaging online like they would in the face-to-face classroom. Often, participants reported contacting families to see how the student was going in the online environment. It was clear that teachers needed to “tread lightly” not knowing the circumstances at home during this time. Andrew also commented that he felt he “had to be very careful that we weren't pushing too hard or give them something they couldn't do” as there was a concern that students would disengage even further.

Jennifer shared a story about a specific student, "He just recorded the answers, and he would skip ahead and get to the end and do the absolute sort of minimal." [Jennifer, Interview 1]. Her story was of a student she described as always engaged in the face-to-face classroom and usually very good at articulating his thinking. Jennifer had noticed his lack of effort online and began making contact encouraging him to "go back and explain, can you please show your strategy, can you please explain your reasoning, we want to see where your thoughts have come from." She noted that it took "a lot of work", but he did "end up trying a lot harder".

There were several suggestions given by participants about why students may have disengaged. A lack of parental support, finding the work too easy or too challenging, feeling isolated, lacking motivation, and struggling to adjust to the online environment were some of the possible reasons. As these students were absent online and often not completing the

tasks, it was difficult for the teacher to pinpoint the exact reason why they may not be engaging.

Jennifer commented in the first interview, "We (the teachers) did a lot of work with trying to support the students who were struggling with the lack of socialisation." Many of the participants did share strategies they implemented to try and encourage those disengaged students to participate online, including making contact with their family, contacting the student to invite them to group sessions, running one-on-one sessions, sharing and celebrating students' work online and creating fun and engaging tasks.

There were various reasons why a student might be disengaged in ERT. Teachers had to use prior knowledge of their students to assess why an individual might be disengaged and decide what steps to take to try and re-engage them.

4.2.1.4 Observed Dispositions During Learning Online. With the lack of opportunities to notice students' thinking online, teachers focused on noticing specific positive learning behaviours that the students exhibited.

Below is a report from Andrew of his experience noticing how his students responded to learning online. There were a range of behaviours and dispositions that participants referred to as “student learning behaviours” or “personal social capabilities”. These were behaviours and dispositions that perhaps the students had not exhibited in the classroom yet, or the teacher had not noticed.

> I guess the personal social capabilities with a few of the students I have really picked up on. Wow, you are this really independent person? You're the person that comes along to these meetings, that gives the feedback, that gets involved, that does things in a creative way, that always completes your task without being told. You can really sort of see these work habits and these personality traits come in that will really develop later on in leadership skills. You know, they might not be the most academically gifted student there, but that they use their ability that they've got. They use their skills, they’re the students that you really enjoy working with, I should say, you’ve worked with all of them, but they're the ones you think, wow, you know you've really got a successful future ahead because of the way that you, you know you just direct yourself. [Andrew, Interview 1]

In this particular example, Andrew had been surprised by some of these positive learning behaviours that some of his students had exhibited, as he had not previously noticed them in the face-to-face classroom. Concerning these, Andrew reflected,

> Some students need that structure, but others actually don't. You (the student) can actually do it by yourself or maybe I'm too structuring in the classroom for people like that, so I guess that's another thing that I sort of learn from this that you know, maybe that free time that independence, that this is your task. Now you have to go and do it yourself. [Andrew, Interview 1]

Andrew was reflecting on his own teaching practices back in the physical classroom and wondering if he had not noticed these positive dispositions to learning yet because students were not given opportunities to demonstrate these in the classroom due to it being too structured.

4.2.1.4.1 Student Confidence. One of the dispositions the participants reported noticing online was confidence. Confidence can be hard to describe and hard to measure (Burton, 2004). However, there is widely held view that performance in mathematics and student confidence go hand-in-hand. When asked, “What’s been a highlight for you recently in maths since returning back to the classroom?” Jennifer reported that some students had exhibited increased confidence since returning to the face-to-face classroom. She mentioned that one particular student had developed this confidence during ERT, and she had noticed it transferred back into the physical classroom: "She really thrived in that, you know, filming herself explaining—articulating her thinking and that kind of thing, where she wouldn't normally have done that" [Jennifer, Interview 1]. Although she was still shy on camera during live sessions, she was enjoying being able to articulate her thinking and share strategies by pre-recording videos and uploading them to their learning platform for Jennifer to see.

There were other instances where participants mentioned students and confidence: "She's just developed this confidence where she'll ask" [Kate, Interview 1]. Kate was referring to a student who, as mentioned earlier, had been "thriving" in the online environment. She had a good set-up at home, had been working hard on her mathematics tasks, and was doing quite well. This increased her confidence, and Kate noticed that she was more willing to give answers and share her thinking in the online environment. Kate commented, "I hope it continues when she gets back to school, I think it will."

In her first interview, Lisa stated, “I do know who’s pretty confident in it and I know who isn’t” [Lisa, Interview 1]. Lisa’s second comment related to her whole class and mathematics in general. As mentioned earlier, Lisa had only met the class once but had not taught the students prior to starting ERT with them. However, she felt that she knew who was and was not confident in mathematics by the time they were ready to return to the classroom.

4.2.1.4.2 Student Independence and Taking Responsibility. Students who are independent learners are able to take responsibility for their own learning (Johnston, 1984). The new level of confidence exhibited by students led to an increase in independence and students taking responsibility for their learning online.

Five participants noticed students who were quite independent in the online environment. In his first interview, Greg mentioned a particular student: "I've got one who has really extended herself and I've seen a lot more of her mathematical thinking from home versus at school. And I think it's been a really good *eye opener*" [Greg, Interview 1]. Greg went on to reflect that it could be her friendship group in the classroom that is holding her back. She usually works with them on group tasks in mathematics and was sitting at the same level as the rest of the group. Greg noticed that she was capable of much more in the online environment.

In the first interview, Belinda spoke of one of her students, an independent learner, saying, "I think they're (the tasks) taking her a long time, but she's done really well… she was such an independent learner" [Interview 1]. Belinda was referring to a student who was not only completing her mathematics tasks independently but challenging herself by going on and attempting the more complex tasks. "In her reflection, she's like 'This was hard, but you know, I think I got it in the end' and… just how persistent she's been with it" [Belinda, Interview 1]. Her reflection indicated that although she found these tasks challenging, she was quite proud of herself for completing them. Given the time constraints in the classroom, Belinda felt she may never have known that the student was capable of this as in the classroom she would have been focused on just completing the task that was set for her. When asked in Interview 2 how this transferred into the classroom, Belinda and Narelle said: "She is a quiet one, but quite bright. She's still quiet, I find" [Belinda, Interview 1]. "But she does – she takes on any extension" [Narelle, Interview 1].

Lisa commented: "Yeah, it's been awesome to see his motivation, yeah, to do more..." [Interview 1]. Lisa's comment refers to a student who worked in her extension group sessions. He never missed a session and completed the extra task that Lisa would leave the group with at the end of every session. Lisa described another student, "Just his willingness to just have a go" [Interview 1]. This student was considered "less capable or confident" but would come to the drop-in session every day and attend other support sessions offered to him. Lisa was impressed with his efforts, "It's really hard for him, but he just keeps trying every day" [Interview 1].

Narelle spoke more broadly about students' dispositions to learning online:

> They (the students) actually ask for help and they read your feedback you've got the time to sort of spend with them, conversing with me, whether it's via email or like some of them would be happy to jump on a zoom, and you'd be able to give that one-on-one attention. [Narelle, Interview 1]

Narelle was referring to noticing the students' independence and willingness to challenge themselves online. She had noted that they were actually capable of going further with their learning than was previously thought. These students took responsibility for their own learning in the online environment. They communicated regularly with the teacher, sought help when needed and responded to feedback.

These examples illustrate that the participants noticed students responding positively to learning online. The participants noticed that these students were capable of doing the work set for them and were willing to challenge themselves. These students adapted to their new learning environment and found ways to interact and communicate effectively with their peers and teachers. Participants did not report on any specific actions for these students, but rather the students were left to continue working independently and at their own pace. Students continued to be supported through drop-in sessions or master classes or communication via email, their online platform or feedback left on work submitted.

In the online setting, participants observed these student learning dispositions they had not previously noticed before going into ERT. Participants in this study shared wonderings during their first interview about how these might transfer to the face-to-face classroom.

4.2.2 *Teachers' Reflections on the Face-To-Face Context*

After months of ERT, students and teachers returned to the face-to-face classroom. As we did not fully know or understand the effects of social isolation, inconsistent structures, and personal circumstances on the students, it was uncertain what the return to the classroom would bring. Knowing that student engagement is important to learning and achievement, re-engaging students back in the classroom with a strong focus on wellbeing was needed. With this focus in mind, teachers first paid attention to students' engagement levels, individually and as a class.

4.2.2.1 General Engagement Transitioning Back to the Face-To-Face Classroom.

School leaders asked teachers to put wellbeing as the number one priority on return to the classroom: "So, we did firstly, our focus for the week was looking after ourselves, health and wellbeing because- a sort of a holistic focus" [Greg, Interview 2]; "But

it’s also student welfare, as well, that you need to keep in mind” [Andrew, Interview 2]; and ”You know it's the wellbeing, doesn't matter if they don't do it (school work)” [Kate, Interview 1]. Jennifer also reported that her school had a similar focus. The teachers were asked by their schools' leaders not to give the students any form of assessment for the first four weeks back in the classroom and instead to focus on the wellbeing of the students and re-engage them back into the face-to-face classroom.

4.2.2.2 Examples of Engagement Face-To-Face. At the beginning of the second interview, each participant was asked, "How have the students been since returning from remote learning?" Participants responded: "Really good, really- 99 percent of the kids are just so appreciative and resilient and just stepped up like they just want to be at school" [Greg, Interview 2]; "Yeah, they were happy (to be back) and it's been really good" [Lisa, Interview 2]; "They're definitely happy to be back, definitely - socially they're loving being together" [Kate, Interview 2]; and "They started off with just as little balls of enthusiasm, so excited to be back and just raring to go, so happy to be in the classroom, so happy to be with their peers, and really eager to learn" [Jennifer, Interview 2]. Although the participants did not refer to what they noticed explicitly (e.g. facial expressions or body language), there were some distinct emotions noticed here, including a level of excitement and enthusiasm from the students. It was clear that students were happy to be back at school.

Participants had discussed strongly focusing on engagement when returning to the face-to-face classroom. During the second interview Greg mentioned "I'm really being mindful at the moment of putting engagement as my number one priority and especially in the maths." He went on to say, "I want as much engagement as I can in every maths lesson.”

There were several quotes where participants reported students enjoying and engaging in fun, hands-on mathematics lessons since returning to the face-to-face classroom: “They’ve been enjoying a lot of the hands-on games, the problem solving, the thinking” [Andrew, Interview 2]; “They got to play games and had fun. It was kind of nice, whereas sometimes in remote learning you couldn’t have fun” [Belinda, Interview 2]; “I mean it’s just the eagerness, they’re really eager to learn hands-on maths” [Greg, Interview 2]; and “So, our aim was to literally engage them back in school through market day which was such a good maths unit but also - engagement” [Sarah, Interview 2]. The participants enjoyed planning hands-on, "fun" mathematics experiences that they felt the students had missed in the online environment.

When discussing her students returning to the classroom, Lisa stated, "They are really good, I felt like I knew them coming back and had that connection with them." Lisa's situation was different to other participants. She had been employed to start teaching the

class at the beginning of Term 2, just when the schools went into the first stage of ERT. Lisa had been in to meet the students at the end of Term 1 just for an hour but had not officially taught them prior to engaging in ERT. Despite having very little information about any of these students, Lisa felt that during her time teaching and engaging with them in the online environment, she had built relationships and got to know her students individually. During her first interview Lisa said,

> I feel like I know them. I feel like I know their families. I've met all the families and I feel like I know the kids. I know their interests, I know who likes Lego, who likes Ninja Warrior. Who loves the AFL. I know all those bits and pieces, but I don't know them in person, sitting in the classroom with their friends. [Lisa, Interview 1]

That social aspect was what Lisa had missed online. In regard to returning to the face-to-face classroom, Lisa said,

> I guess it was weird the first couple of weeks seeing who their friends were because they told me, but it was hard for me to connect the friends (online), and so then seeing who they are chatty with and who they get along with and seeing them in a social way was a bit different. [Lisa, Interview 2]

Lisa found that in the online environment, she could engage with the students and notice them as individuals, finding out what they know, who they are, what they like and what their feelings towards mathematics were. Lisa reported on running small group sessions and providing opportunities for whole class "fun" social activities to engage the students and to get to know them.

On returning to the face-to-face classroom, Lisa had all this information about individual students and was then able to get to know them on a more social level in the classroom. Lisa reported using group tasks to see how they interacted together. Lisa had learnt during ERT that many of her students had a negative mindset towards mathematics, which led to her incorporating many mathematics games in her lessons and trying to make them "hands-on" and "fun". An example that Lisa gave was a volume and capacity lesson that they completed outside in the sandpit.

4.2.2.3 Examples of Disengagement Face-To-Face. Most of the reports from participants around re-engaging in the face-to-face classroom were quite positive. Students were generally excited about being back at school after spending a significant amount of time in ERT.

Lisa was the only participant to share an example of an issue with engagement. She was surprised that her class seemed to have a very negative mindset towards mathematics,

causing them to disengage from the subject. Lisa had only met the class for one hour before entering ERT and mentioned that one of the first questions they asked her was, "Do you like maths?" Lisa responded, "Yeah I love maths, I love teaching maths." The response she got in return was, "Oh not you as well. Well, we don't like maths in here." Lisa reported that she had never seen anything like this before, saying, "It (their mindset) is such a blocker for this cohort. It was right from the outset, and I am—well I am going to change that."

Lisa spoke of one student, Millie, who was the most negative. She reported using Millie as an engagement gauge. Lisa had told Millie that she would ask her what she thought at the end of every lesson. She said Millie was reluctant to give her too much or look too excited, but she could see she liked it more. Lisa commented on what she had heard from other students: "They are at least commenting 'that wasn't so hard' or 'that was fun', 'Oh, maths is fun', 'I didn't realise maths could be like this.' They are just like—oh we love maths so much now" [Interview 2]. Lisa had been determined to show her class that mathematics can be enjoyable and help them see its purpose and learn to love it again.

4.2.2.4 Observed Positive Learning Behaviours in the Face-To-Face Classroom.

On return to the physical classroom, teachers continued to notice students' positive behaviours to learning. Some of these dispositions were first noticed in ERT and transferred back into the face-to-face classroom. The participants were more focused on noticing these dispositions back at school after observing them in the online environment.

4.2.2.4.1 Student Confidence. There were a few reports of students who had exhibited a new found confidence in the online environment. In her second interview, Jennifer reported, "A couple of my kids have developed a lot more confidence in asking for help, which has been great." When questioned further about these students, Jennifer said they had demonstrated increased confidence online and, when working back in the physical classroom, were asking for help more, particularly in small group situations.

The following comments from Belinda and Narelle are regarding the same student, Bella: "I think just that self-belief and that confidence that someone thought she could do more than she could do" [Belinda, Interview 2]. "It was her confidence and self-belief. So having that period of time where she's like okay, I'm doing the orange tasks and I'm getting them right, maybe I can do it" [Narelle, Interview 2]. "Even in classroom discussions, you see her putting her hand up a bit more and she's not afraid to get it wrong anymore, I don't think" [Belinda, Interview 2]. Belinda's first comment refers to Bella's mother. As mentioned earlier, Bella's mother made contact with Belinda and Narelle, suggesting that Bella be offered the opportunity to try the "harder" mathematics tasks as she believed that Bella could do them. The fact that Bella knew her mother had made contact with the teachers to give her a more challenging task already gave her the confidence to give these tasks a go. As Narelle's

second comment points out, after trying several tasks, Bella realised that she could do more challenging tasks, which increased her confidence further. This confidence has since transferred into the classroom, where Bella was still trying more challenging tasks and putting her hand up more to share her thinking.

4.2.2.4.2 Student Independence and Taking Responsibility. The participants recalled noticing students exhibiting independence and taking responsibility for their learning once they returned to the face-to-face classroom.

For example, Lisa shared a story: “He said, ‘No I want to work it out’. So, he just sat in a different spot and then he was reading through it, and he actually sat there and did the whole thing” [Lisa, Interview 2]. Lisa was referring to a student who worked in her extension group during ERT but was putting minimal effort into the tasks. From what Lisa had seen during ERT, she noted that he could be quite lazy and was good at playing the *class clown*. The student was taking more responsibility for his mathematics learning in the face-to-face classroom Lisa noticed.

Greg also shared an example of a student taking more responsibility:

> He just doesn’t get distracted by the boys, he thinks by himself about his learning, he’s completing tasks, he’s not coming to me 20 minutes later and saying I’m just so confused, he’s just like head down, getting my work done. [Greg, Interview 2]

Greg referred to a student in his class who had done a "complete flip." Greg described the student as one who “would get lost in classes, he would get distracted by any of the—you know he was like the sheep in the class, he would follow any boy and he would get distracted by them and then get lost, get confused and get no work done.” He mentioned that ERT did not really suit him either. However, he had returned to the face-to-face classroom with a *new appreciation for school* and was ready to persist with any task he was given.

In her second interview, Belinda spoke of a student and what she had noticed on return to the classroom: "She's very independent… She's quite good at knowing herself." [Interview 2]. Belinda noted that she was happy to move fluidly between groups in mathematics lessons: “She’s like I’m stuck, I’m coming back. So, she’s not afraid to jump in and out wherever she needs to” [Belinda, Interview 2]. Belinda noticed that this student was quite independent and could take responsibility for her own learning needs.

Greg reported, "It was interesting that they didn't need my support as much as I thought." His comment was in reference to a particular task set in the classroom. He had given the students an open task of designing their own mini golf course. They had just

finished a whole unit on measurement, and Greg said as a part of this task, "I asked them just to - show me your mathematical thinking in your mini golf course." Greg said the students could design their own task to meet their individual needs, focusing on showing what they knew and areas they felt they needed more practice in.

Jennifer mentioned that a couple of her students were now asking for help more often. She said, "It's been great to kind of see their thinking and them take on what you're saying after they've asked for help." Now these students were taking responsibility for their learning, Jennifer was able to better assist them, and she was enjoying seeing them use the information and help she gave them to move forward.

4.2.3 *Summary*

Numerous studies on engagement have concentrated on students' experiences in mathematics. The ERT experience was new for everyone. Teachers were uncertain how their students would react to learning in this unfamiliar environment. Consequently, the participants directed their attention to observing the students' levels of engagement, particularly noticing changes, or variations from their anticipated expectations. The emphasis on engagement remained strong as students returned to the face-to-face classroom. Since there was no data prior to ERT in this study, it is unclear whether this focus on noticing engagement in the face-to-face classroom represented an increase compared to the time before entering ERT.

The participants in this study reported noticing students who were "thriving" online as well as noticing students who became disengaged. These reports frequently highlighted students who "surprised" the participants. What they noticed online differed from what they were expecting based on their prior knowledge of the students before entering ERT. For some students, the online environment proved conducive, as certain students found it easier to communicate digitally with their teachers and work without the distractions of the face-to-face classroom. Conversely, other students encountered challenges with online learning, preferring to be in the face-to-face classroom, collaborating with their peers and having the teacher close by for assistance when needed.

The teachers' responses to observed student engagement levels differed between the two contexts. In the online environment, it was difficult to know what factors contributed to their level of engagement and what action to take. Faced with disengaged students, participants developed new strategies to implement online. Participants in this study reported employing various strategies, such as conducting synchronous lessons and small focus groups to enhance visibility and interactions with students and offering more student choice. Additionally, contacting parents to gather more insights into a student's experience with ERT

helped inform appropriate actions. In the face-to-face classroom, the teachers could see physical reactions and responses to gauge student engagement levels. This enabled them to make real-time decisions on whether and how to respond.

Participants did not provide any detailed commentary on specific actions for students they noted as engaged in either context. Beyond offering encouragement, participants allowed students to proceed without further investigation. This implies the participants acknowledged the students' level of engagement and deemed their current efforts satisfactory, signalling that no additional intervention from the teacher was required.

Notably, the participants observed a rise in positive dispositions in their mathematics learning in the online environment. These students were exhibiting increased confidence and displayed the ability to take responsibility for their own learning. The online environment suited some students. There were no distractions, time restraints or comparisons with peers. Moreover, participants indicated that these positive dispositions often translated into the physical classroom. Reports highlighted increased confidence among students, reflecting in their willingness to actively participate by raising their hands, sharing ideas, and overcoming the fear of giving a wrong answer.

Although observing students' mathematical thinking and gathering evidence of their learning online was challenging, the insights gained from noticing individual students and their positive learning behaviours proved invaluable in understanding students as learners of mathematics. In response to this individualised noticing there were reports of increased opportunities for tailored, personalised learning experiences for specific students.

After observing these student dispositions in the online setting, teachers reflected on their face-to-face practices, considering how to create an environment that would sustain and encourage these dispositions upon returning to the classroom. Once back in the classroom, participants continued to focus on these dispositions, eager to see if they would persist in a face-to-face context.

4.3 Communication With Families

Effective communication between teachers and families enables the exchange of information regarding the student, fostering strong connections between the home and school environments. The results of this study revealed that participants demonstrated effective communication with the families of students in their classes in both contexts with an increase in communication while online.

4.3.1 *Teachers' Reflections on the Online Context*

There were reports from the participants where communication with families allowed them to notice more in the online environment. The lack of face-to-face contact with students meant teachers were unsure how their students were coping emotionally at home or how they were progressing with their learning. During ERT, the families became a valuable source of information for teachers to know more about their experiences learning from home. In her first interview, Jennifer stated, "We got to know the parents really – some of the parents really well" [Interview 1]. Jennifer reported that she spent a lot of time making calls home to families to support them with the transition to online learning. Below are reports of teachers contacting families as well as families contacting teachers.

4.3.1.1 Teachers Making Contact With Families. Participants in the study shared instances of reaching out to the families of their students during ERT. Jennifer reported examples of contact she made with various families: "So, his parents were amazing, and they went back and tried to sort of help him through that" [Jennifer, Interview 1]. Jennifer was referring to one of her "strong maths students", who did not appear to be putting in as much effort during ERT. He was quite an articulate student who was struggling to show his thinking in the online environment. Jennifer contacted the family to find out how best she could support him with his learning. In the same interview, Jennifer shared another story of a student who had "blown her away" in ERT with the way she was challenging herself and the level to which she was able to take her own learning: "And her parents have both been working really hard and she's had no—she's had no help, and we know this because we've spoken to her parents and she's done it all by herself" [Jennifer, Interview 1]. Jennifer had checked in with this family to see whether the student had been seeking help from anyone at home.

4.3.1.2 Families Making Contact With Teachers. There were reports from the participants where the families contacted them during ERT. For example, Greg spoke of one particular student:

> The family has contacted me saying she's a little bit worried about coming back, but I've got that in my thinking about our first week back. … So, it's something that I'm just noticing, keeping in the back of my mind that she will need that support back at school. [Greg, Interview 1]

Greg explained that although this student was typically reserved in the face-to-face classroom, they had increased communication with him in the online environment. He perceived that the student found solace in "the quiet space and the time to think by herself"

during ERT and expressed apprehension about returning to the face-to-face classroom. Greg was considering ways he could support her back at school:

> We've got a bit smaller classroom, we've got some extra space and quite larger rooms, so there might be something thinking about having a breakout table for her that she can go work a bit away from the other tables. [Greg, Interview 1]

Kate provided an example of families reaching out to her regarding their child finishing their work too quickly: "We'd have kids again one of these parents where they just finished immediately and it's like there's nothing to do. No, they haven't finished, they haven't even really tried, they're just saying they can do it" [Interview 1]. Kate clarified with families that their child had not really "finished" and could invest more time and effort into their tasks or seek ways to challenge themselves.

Lisa shared several examples of families reaching out when their child encountered challenges with the tasks. One example was a parent who was seeking more support for their child. "… his parents approached me and said, 'I think he needs some support.' I said 'Well, I'm on there. He needs to come on.'" [Lisa, Interview 1] In this case, Lisa informed the family that she was available online at specific times each day, and students could join to complete their tasks with her.

Jennifer had been contacted by one of her families when one of her students was experiencing some anxiety when completing her mathematics tasks at home:

> We had a big discussion with her mum, her mum's absolutely beautiful, and we just talked about, you know, her—when she feels anxious about learning, she just completely shuts off. So, she was at that point, and so, what we did is we did some one-on-one sessions with her to try and reconnect and help her feel a little bit more calm and give her a bit more explicit teaching on that topic. I think it was fractions we were talking about. And then we ended up deciding—we changed it slightly for her—so, we decided with her mum that she would be in two groups. So, we put her in—she was in blue group, which was the high group, but we gave her that, and then we also gave her the activity for the green group, which was the medium group. [Jennifer, Interview 1]

This illustrates a situation where the parent shared crucial information with Jennifer about the student. Jennifer learned that the student was experiencing some anxiety while completing her tasks at home. Collaborating with the student's mother, Jennifer devised a plan to support the student. The plan involved granting the student more autonomy in selecting tasks and participating in one-on-one sessions with Jennifer.

4.3.2 *Teachers' Reflections on the Face-To-Face Context*

With very few reports of contact with the families in the face-to-face classroom, it seemed that teachers did not feel they needed any information from the families to notice and respond in the face-to-face environment.

4.3.2.1 Contact Between Teachers and Families. There were three reports of communication with families in the face-to-face classroom. The first was from Lisa, who was the only one to discuss making contact with families: "I contacted a couple of parents and said, 'Look I am doing this for them' and they said 'Yeah, we know we've heard—they come home, and they are so excited about it'" [Interview 2]. Lisa had contacted the families of the students in her class to whom she was providing an extension task. Lisa only took over teaching the class at the beginning of Term 2 and had not met the students before ERT, so she may have been using this communication as a way to continue getting to know her families.

There were two reports of when the families contacted the participants. Greg shared: "Quite often, I'd get an email from Mum or Dad (saying) 'she came home, she's a little bit upset, she found it really difficult, and she could see that other students are getting it'" [Interview 1]. Greg was referring to a student who was not confident to tell Greg when she was experiencing difficulty with her mathematics tasks in the classroom, so the family would email and let him know. This report from Greg was from the face-to-face classroom prior to ERT. As mentioned earlier, Greg reported that this student was more confident in contacting him herself when she was experiencing difficulty during ERT. Greg did not discuss this student during Interview 2.

Andrew also shared an example of contacting the family when a student who was having some issues with his behaviour since returning to the classroom:

> And so had a phone call with the mum today, had a bit of a chat to see if we need to put together an action plan for him, bit of a contract. We do need to modify his program, but regardless, we still expect him to do the requirements as needed to get in and prepare for Grade 5 next year. [Andrew, Interview 2]

This was an example of when Andrew felt it necessary to contact the family about their child's behaviour at school. Andrew felt this behaviour was affecting the student's learning and stopping him from progressing. The family worked with Andrew to implement a plan that could best support the student moving forward.

4.3.3 *Summary*

Effective communication between teachers and families promotes a shared responsibility for the student's success. A significant difference between the two contexts was the teacher's level of communication with families. Participants in this study reported increased communication in the online environment to gain more information regarding the students' mathematics learning. Without seeing the students working on their tasks, participants relied on the families to be the "eyes and the ears" and let them know when their child was struggling, or the learning was too easy.

There were few reports of communication with families on return to the face-to-face classroom. It could be that communication may have occurred, but the participants in this study did not report it, or the participants were able to physically observe the students back in the face-to-face classroom and were confident to make decisions about when and how to act based on their own observations and judgements.

4.4 Summary

The themes that emerged from the data analysis were reported in this chapter. Three key themes: Adaptions to mathematical instruction: teacher responsiveness, Student participation and dispositions, and Communication with families were explored from two different contexts, the online environment, and the face-to-face classroom. Reports of the meaningful moments related to mathematics that the participants noticed, and the actions they took as a result of what they noticed were presented. Each theme was illustrated using participant quotes from the interviews. Comparisons were made between the two environments, and similarities and differences were noted.

Key findings from the research highlighted the critical role of student engagement across both online and face-to-face contexts. Teachers closely observed students' engagement levels and leveraged their understanding of individual students to decide when and how to intervene. Interestingly, participants noted instances where their observations challenged prior assumptions, including identifying specific learning behaviours that had not been previously evident in the face-to-face classroom before transitioning to remote learning. This focus on engagement and positive learning behaviours online led teachers to reflect on their practices and maintain attention on these dispositions upon returning to the classroom.

The findings also demonstrated how teachers adapted their teaching practices to navigate the unique challenges of each context. In the online environment, participants faced reduced opportunities to notice and act in real-time, prompting them to implement strategies to better align online learning with face-to-face experiences. These strategies included creating more opportunities for interaction through synchronous learning, small

focus groups, and offering greater student choice. Differentiation proved more challenging online, leading teachers to rely on levelled tasks. With less direct visibility into student progress, communication with families increased, fostering collaboration to provide tailored support for each learner.

Upon returning to the face-to-face classroom, participants structured learning environments to capitalise on what they had learned during remote teaching. They reported using more open-ended, inquiry-based tasks to create opportunities for real-time noticing and to ensure the right level of challenge for each student. These adjustments enhanced their ability to differentiate instruction effectively and adapt learning experiences to meet individual student needs dynamically.

Chapter 5: Discussion

The purpose of this chapter is to make meaning of the key findings presented in Chapter 4 in relation to the research questions and provide a critical analysis by connecting these findings to the existing body of literature underpinning this study. The aim of this study was to investigate teachers' perspectives of noticing as a key action of informal formative classroom mathematics assessment. In particular, the aim was to identify what focuses teachers' attention to notice moments meaningful to mathematical learning in different contexts. Ways in which the information gained through these moments was used by teachers to enhance student learning were also investigated. Data were collected through two semi-structured interviews in 2020, which allowed for a comparison between two contexts: the online environment during Emergency Remote Teaching (ERT) and the face-to-face classroom (after ERT).

Due to the unprecedented challenges posed by the COVID-19 pandemic, this study was unable to incorporate classroom observations. Consequently, the findings relied exclusively on data obtained through interviews. During these interviews, teachers enthusiastically recounted their experiences and shared anecdotes of their students, reflecting on specific moments. It is worth noting that teachers recalled these moments vividly and felt they were worth sharing with the researcher in answer to the interview questions. This process aligns with a term from Mason (2011) known as *post-paring*, as teachers recounted important events, reflecting on the meaningful moments they noticed, which subsequently impacted future noticing.

While this study underwent changes, it is important to acknowledge that the COVID-19 pandemic introduced unprecedented shifts in education, presenting a unique opportunity for researchers to explore its impact on teaching and learning. Educational research conducted during this time, including the present study, has the potential to provide valuable insights into diverse learning environments and innovative teaching practices.

The following discussion is presented in three sections focused on each research question. In the first section, a discussion is presented regarding findings for Research Question 1: What focuses primary teachers' attention to notice moments meaningful to mathematical learning? In this section two key areas of focus will be explored: engagement and students' learning dispositions drawing connections to teacher-student interactions and the importance of social interactions and collaboration in the learning environment.

In the second section, a discussion is presented concerning findings for Research Question 2: How do teachers respond to what they notice? In this section the varied approaches employed by the teachers in responding to students' needs in the two different settings will be discussed. This encompasses providing feedback, adjusting tasks, and regularly reflecting on teaching practices. This discussion will include specific strategies such as the use of small focus groups, "check ins", and insights from communication with families.

In the last section, a discussion is presented about the findings for Research Question 3: Regarding mathematics learning, how does what teachers notice and respond to in the online context compare to the face-to-face context? In this section, the focus on engagement is discussed as a similarity. Subsequently, notable differences between the two contexts will be discussed, including observing students learning dispositions online, the dynamics of teacher-student interactions, approaches to providing feedback, the use of student choice and how teachers structured the learning environments, and the increase in communication with families in the online environment.

5.1 Focus of Teachers' Attention

In response to Research Question 1, teachers in this study placed particular emphasis on student engagement. This focus in the online learning environment could be attributed to the new situation teachers and students found themselves in. It was a sudden transition to this learning context, and concerns were raised about how the students would respond to this new environment. Noticing students' thinking during ERT was more challenging, hence teachers focused their attention on what was observable.

5.1.1 *Engagement*

According to the participant's accounts, students displayed some form of behavioural and emotional engagement, but little cognitive engagement could be discerned in the online environment. Teachers primarily observed behavioural engagement, noticing when students were actively engaged and completing assigned tasks. This finding echoes the work of Fredricks et al. (2004). In the face-to-face mathematics classroom, teachers could observe students working on tasks and listen to or engage in conversations. These actions provided insights into the students' cognitive engagement as noted by Jacobs and Empson (2016). It was in these moments where teachers could elicit student's thinking, moments they missed during ERT.

Given student engagement in learning is considered a significant factor in students' academic achievement (Fredricks et al., 2004), ensuring students are engaged and monitoring this is an important aspect of a teachers' practice. Teacher participants reported that student participation levels during ERT were unexpectedly varied. There were numerous

accounts of increased engagement, with some students thriving online, a discovery similar to one found by Kim and Asbury (2020). However, this differed from the findings of Bissessar (2021). In her study, eighty-one Trinidadian and Grenadian teachers were surveyed to gain their perspectives on student attendance, engagement, and motivation during the start of the COVID-19 pandemic. Bissessar (2021) found that most students' engagement levels mimicked those previously observed in the classroom. However, teachers in this study reported students who surprised them as what they observed differed from what was expected based on their prior knowledge of the student. While positive reports of engagement might typically warrant no additional action in the face-to-face classroom, in this study, the surprising examples of increased engagement online prompted two participants to analyse their teaching practices. As they reflected on those students' experiences online, they considered how their classroom practices might affect the students' engagement. Teachers reported wanting to provide mathematical experiences focusing on maximum engagement in each lesson.

A study by Skilling (2014) identified specific teacher practices that can either promote or hinder students' engagement in mathematics. Making real-life links, following student interest, encouraging students to take control of their own learning, and building strong trusting relationships promoted engagement, whereas not attending to engagement issues and focusing more on completing curriculum requirements hindered engagement (Skilling, 2014). When reflecting on their own practice, teachers in this study contemplated adjustments to their practice they could implement on return to the face-to-face classroom that could increase student engagement. One participant wanted to implement fifteen-minute one-on-one sessions in the classroom with either the teacher or an aide for her PSD (Program for Students with Disabilities) funded students. The aim was to assist the students in starting their task and then allow them more time to complete their work independently, encouraging the students to take responsibility for their own learning, a practice Skilling (2014) found promoted student engagement. The teacher or aide would still regularly check in with the students during the lesson but would not provide any more one-on-one support unless it was necessary. Another participant was considering a student with whom he had increased communication online. It appeared the student liked the quiet space to work in at home and was more comfortable with the private, digital communication with her teacher in the online environment. The teacher was considering setting up a "breakout table" that would be a space in the classroom where this student (or others) could go if they were looking for a quiet area to work away from their peers. Also, in line with the work of Skilling (2014), one teacher planned lessons for the face-to-face classroom, with engagement in mind, based on what she had learnt about her students' interests online. After learning that many of her students love playing with Lego, she decided to implement a Lego shop lesson where students build items to sell to their peers. These are just a few examples of the participants

wanting to further promote student engagement, recognising the pivotal role of the learning environment in the mathematical success of students. In addition to fostering engagement, teachers needed to be aware of signs of student disengagement and employ strategies to quickly re-engage them.

While instances of student disengagement were noted in the online environment, the teachers acknowledged that effectively engaging students without the interactions of their peers and the usual atmosphere of the face-to-face classroom was challenging, echoing findings from Kalogeropoulos et al. (2021). According to Boaler (2000), social interaction is considered important to mathematics learning and directly impacts students' engagement. Trying to re-engage students who became disengaged during ERT was challenging. Not being in the same physical space, the participants reported turning to families to gather more information and seek assistance in determining the most effective ways to support the students. While various studies have discussed parents' involvement during ERT in helping their children with schoolwork (Bissessar, 2021; Downton et al., 2022; Garbe et al., 2020), this study highlighted increased teacher-parent communication. Teachers relied on parents to act as their "eyes and ears", providing information that was inaccessible to them in online learning. Communication is an element that Vickers and Minke (1995) found to be important in developing parent-teacher relationships. Establishing strong connections between teachers and families enhances student engagement and can significantly impact a child's academic success.

Maintaining engagement was a critical factor for success in online learning during ERT. Adding to the body of literature on students' engagement in online learning, Khlaif et al. (2021) identified several factors that affected student learning online during the crisis, including teacher presence, quality of content, student attitudes, and home learning environments. Not knowing if any of these factors affected their students or how they coped with isolation and learning from home could contribute to why teachers' attention remained closely focused on student engagement on return to the face-to-face classroom.

In their second interview, teachers in the current study displayed genuine enthusiasm for being back in the classroom and teaching mathematics. They shared in-depth stories involving student interactions, giving feedback in real-time, offering student choice, and utilising real-life, incidental teaching and learning opportunities. As highlighted by Attard (2012), these aspects are important factors in creating an engaging mathematics classroom environment. Upon returning to face-to-face teaching, teachers reported their observations of how students behaved, the feelings they expressed, and of noticing students' mathematical thinking. By observing and interrelating the three areas, behavioural, emotional, and cognitive engagement, teachers gained a richer understanding of students'

overall engagement levels, as emphasised by Fredricks et al. (2004). This proved valuable, as there were very few reports of disengagement in the face-to-face classroom. Students who exhibited high engagement levels in the online setting continued to demonstrate such commitment in the face-to-face classroom.

Acknowledging the lack of social interactions and collaboration during online learning, teachers intentionally created numerous opportunities for collaboration on return to the classroom. These opportunities encouraged social participation and also facilitated more student-teacher and student-student interactions. Research by Zhang and Cao (2022) underscored the strong connection between classroom interactions and students' cognitive development. Once teachers in this study were confident that students were effectively engaged in the mathematics, they could redirect their focus to noticing and eliciting students' thinking through in-the-moment classroom interactions. Various teacher actions related to observations of students' thinking will be discussed in the next section.

With increased opportunities for collaboration and social interaction, teachers recounted witnessing students' moments of self-discovery in the face-to-face classroom. These *ah-ha* moments symbolised students' successes in their mathematical learning, evoking excitement, and inspiration. These instances represent the transition for students from confusion to clarity, as described by Solomon (2010).

5.1.2 *Student Dispositions*

With the focus on observing behavioural and emotional engagement online, student dispositions became an additional focal point of teachers' attention. This new learning environment allowed the teachers to notice their students more as individuals, highlighting these dispositions for specific students. Participants noted positive changes in several students' dispositions towards learning, revealing behaviours not previously evident in the face-to-face classroom. These behaviours may not have been previously observed due to the socially interactive nature of the classroom, where teachers were typically focused on observing students' thinking more than their behaviours and dispositions. Teachers reported some students demonstrating increased confidence and greater independence, with students taking more responsibility for their own learning. Several studies have highlighted the importance of noticing and promoting these dispositions, finding a link between these positive behaviours and increased learning outcomes, see for example, Huda and Syafmen (2021) and Minarti et al. (2020).

Following ERT, teachers remained focused on noticing positive dispositions, seeking to know whether they persisted upon return to the face-to-face classroom. According to the

teachers' reports, students who pleasantly surprised them during online learning consistently exhibited these positive dispositions upon returning to school.

Sherin and Star (2011), proposed narrowing the focus of attention, emphasising how teachers can take an active role in shaping classroom events to facilitate certain kinds of observations. This aligns with the work of Jazby (2020), who stated that if teachers are tactical about how they set up the learning environment, it could make it easier to notice and respond to students' mathematical thinking in the moment. In this study, teachers directed their attention towards student engagement levels and positive dispositions while learning online, maintaining this focus after returning to the face-to-face classroom. By considering the positive dispositions noticed online, teachers reflected on their teaching practices and the learning environments in their face-to-face classrooms.

According to reports from the teachers in this study, it appears they intentionally structured the learning environments to shape what occurs and narrow their focus for more effective noticing and responding. In the online environment, this included synchronous learning opportunities, one-on-one sessions, digital communication, and increased contact with families. Some strategies were similar in both settings, such as running small focus groups and offering student choice. The face-to-face classroom also saw the use of open-ended, rich tasks and collaborative learning opportunities aiming to foster more classroom interactions and create opportunities for noticing and responding in the moment. Implementing these strategies provided more informal assessment opportunities for teachers to gather rich evidence of student learning.

5.2 Teacher Responsiveness

Teaching practice in which teachers make adjustments during instruction based on students' thinking is known as *responsive teaching* (Jacobs & Empson, 2016). Drawing on their observations, teachers determine when and how to intervene, tailoring their responses to the specific context. Research Question 2 concerned teacher responsiveness to what they noticed and will be examined by discussing the findings in relation to previous research.

5.2.1 *Learning Opportunities*

The first example of teacher responsiveness was the quick adaption to online learning. This was a challenging task given that the participants lacked prior experience in online instruction and were only given a couple of weeks to implement this change. Teachers reported that an initial adjustment was required to their teaching methods, mathematical content, and daily lesson plans to suit the virtual setting. The teachers consistently engaged in an ongoing process of reflection on this new experience, making continual adaptions based on their observations or limited observations of the evolving

needs of their students. Faced with the absence of a shared physical space and the limitations of being unable to visually observe and engage with the students in the usual way online, the teachers found there were fewer opportunities for active noticing. To address this challenge, teachers introduced synchronous learning opportunities in the second phase of ERT to emulate a more traditional classroom setting in the online environment and to provide additional opportunities for noticing. Integrating these “live” lessons increased opportunities for both teacher-student and student-student interactions, leading to increased student engagement. This finding aligns with the work of Aguilar et al. (2022) who found a strong correlation between live instruction and student engagement in online learning.

Effective teacher-student interactions play a key role in fostering positive teacher-student relationships (Jerome & Pianta, 2008). A strong teacher presence facilitates meaningful discussions with the students and provides opportunities for student voice, allowing teachers to notice and respond to meaningful moments that offer rich evidence of student learning. Teacher presence was a noted concern during ERT as online learning predominately took the form of asynchronous learning (Sullivan et al., 2020). The lack of teacher presence during the initial stages of ERT, where asynchronous learning opportunities utilising recorded videos, slides or videos from external sites such as Khan Academy, led to reduced student engagement. In this study, synchronous learning opportunities were introduced through online platforms such as Webex or Zoom, similar to a study by Russo et al. (2021). Transitioning to more synchronous lessons created opportunities for increased teacher presence and fostered an environment that more closely resembled face-to-face teaching and learning. While not exactly the same, these synchronous learning opportunities created more chances for noticing meaningful moments.

5.2.2 *Feedback*

Adapting the teacher practice of noticing and responding in the online environment posed a particular challenge, mainly attributed to the delay in digital communication, making timely feedback difficult. Similar findings were revealed in the work of Potyrała et al. (2021), who reported that responding to students in the online environment extended from three minutes to three days. Providing instant feedback became impractical for teachers, a practice more easily implemented in the face-to-face classroom.

Teachers in this study shared accounts of strategies they implemented to adapt their noticing and responding practices to the online learning context. One participant opted to deliver all her feedback verbally, utilising a recording function available through the school’s chosen online platform. She noted that the students were more likely to engage and respond, creating an opportunity for a *classroom-like* conversation, akin to the mathematical exchanges she valued in the face-to-face classroom. A review conducted by Zhang and Cao

(2022) of recent classroom interaction studies specific to mathematics education findings revealed a strong connection between classroom interactions and student cognitive development. This teacher valued these interactions and found a technique that generated similar conversations online through recorded audio exchanges.

5.2.3 *Individual Interactions*

Another example of adapting to the online environment came from a participant who discussed using check-ins in the physical classroom to monitor specific students' progress, provide feedback and assist those requiring support. *Check-ins* is a term the teacher used to describe a formative assessment practice where the teacher initiates a conversation with a student, allowing the teacher to elicit the students' thinking, observe the student's performance on a task and informally assess the student's learning. Teachers can then offer feedback that the students can use to enhance their learning (Goos, 2020). Informal formative assessment practices that teachers blend into everyday activities can be used to collect evidence of student learning in the moment (Sezen-Barrie & Kelly, 2017). To mimic this practice online, one teacher implemented a morning focus group session where the students could remain online after the class meeting to review the previous day's task. The teacher missed the ability to assist them as they worked on the task and aimed to check students' understanding and ensure they still received individual mathematics support if needed while learning online.

5.2.4 *Level of Challenge*

The findings in this study highlighted a distinction between how teachers addressed the students' diverse mathematical experience and knowledge in their face-to-face classroom compared to the online context. In the physical classroom, teachers can adjust the levels of challenge for students in the moment. A study by Russo et al. (2021) found that teachers were more reluctant to allow their students to struggle in the online environment, lacking teacher presence and opportunities for collaboration with peers. Effectively catering for the learning of all students was not easy to do online as noted by Kalogeropoulos et al. (2021).

Teachers in this study reported employing various task types, different mathematical content, and a broader range of activities during ERT, to ensure that the learning was at the right level of challenge for each student. These decisions appeared to be motivated by student engagement. The teachers expressed concerns about potential disengagement of students if the learning provided was too easy or too difficult. This concern aligns with a finding from a study by Lepp et al. (2021) indicating that student wellbeing influenced teachers' decision-making regarding their teaching during online learning. In Lepp's study,

teachers were cautious about overburdening students with increased workload during ERT. Teachers reduced the student workload to manage their own, employed strategies such as paired and group work to reduce the feedback requirements, and delivered whole class feedback via Zoom rather than providing individual feedback. This contrasted with the present study's findings where the teachers were creating between three and five different levelled tasks for each lesson. Despite the workload associated with generating multiple tasks, teachers deemed it necessary in the online environment to effectively challenge each student and maintain their engagement in the learning process. The teachers also provided written feedback to their students this was more than was expected of them by their schools. With reduced face-to-face interactions, teachers felt compelled to provide feedback to address a misconception or acknowledge students' achievements.

As well as creating a range of different tasks, it is important to note the parents' involvement in ensuring the right level of challenge for their child. As mentioned earlier, the participants in this study reported that the parents were their *eyes and ears* during ERT. This involved communicating with parents and working in partnership to provide learning opportunities that met the students' needs.

As previously mentioned, the online learning environment allowed teachers in this study to notice their students more as individuals. Despite the persistent limitations in online interactions and collaboration compared to the face-to-face classroom, teachers gained a deeper insight into certain students. They observed how they adapted to learning in the new environment, detected changes in engagement levels, and identified when the tasks assigned were not optimally challenging. Many of these individual student observations proved surprising to the teachers, often different from their initial expectations. As mentioned earlier in this chapter, this includes the learning dispositions that the teachers first reported noticing in the online environment. These observations enabled them to create personalised learning opportunities in the online learning environment, addressing specific individual learning needs. These opportunities included being offered more than one task, attending one-on-one sessions and small focus groups, having more student choice, and increasing individual feedback, with the opportunity to engage in conversation-like communication through various digital platforms.

While these personalised learning opportunities proved effective for students who took advantage of them, teachers appreciated the ability to notice and respond in real-time upon their return to the face-to-face classroom.

5.2.5 *Learning Together*

During the COVID-19 pandemic, both teachers and students experienced a significant amount of time learning from home and practising social isolation. Upon return to the classroom, the teachers in this study included more collaborative learning into their mathematics lessons to encourage social interaction. Teachers observed that most students were pleased to be back in the school environment and were eager to engage with their peers. They also noted that the positive learning behaviours initially observed in the online environment had transferred to the face-to-face classroom.

One participant in this study reported having missed what he termed “moment learning” for students in the classroom. This referred to those moments in the face-to-face classroom where teachers can use students’ work as a discussion point, identify and act on a teachable moment, or utilise incidental teaching opportunities, for example, highlighting real-life examples of angles in the classroom environment. A teachable moment can be described as teachers acting in the moment, responding to a student’s answer or comment to address a misconception or enhance conceptual understanding (Muir & Watson, 2017). More teachable moments can arise by providing students with opportunities to interact and engage in rich discussion. Teachers in this study shared accounts of various teachable moments demonstrating their ability to recognise and embrace these opportunities in the classroom.

Teachers also expressed appreciation for the opportunities to observe the students’ actively engaging in tasks and “see” their thinking in the moment. Their commitment to replicating these practices for the online environment emphasised the high value they place on such interactions. The capacity to observe the students in “real-time” enabled teachers to assess engagement levels, gauge students’ understanding of the learning and offer timely feedback.

Constructive social interactions in the mathematics classroom contribute to positive mathematical learning experiences for students (Boaler, 2000). As reported by Pianta et al. (2012), enhancing the quality of teacher-student interactions can lead to increased student engagement and, ultimately, improving student learning and development. In the context of their study, increased engagement was not only an outcome but also served as a mediator, influencing the teachers’ impact on student outcomes through their interactions with students. In this study, teachers noted minimal disengagement in the face-to-face classroom, likely attributed to their eagerness to return to school and increased opportunities for social interaction compared to the online environment. Maintaining student engagement was less of a challenge in the physical classroom, where teachers and students could

interact and actively involve each other. In this setting, teachers can quickly identify signs of disengagement and implement suitable strategies to re-engage the student in that moment.

Upon return to the face-to-face classroom, teachers reported embracing opportunities to re-establish interactive engagement with students. They discussed conducting regular check-ins where students were provided with immediate assistance, assessed levels of understanding, posed thought-provoking questions to stimulate students' cognitive processes, and actively engaged in the learning. This approach aligns with the concept introduced by Clarke (2004) known as *between-desk instruction*. In this practice, teachers engage in targeted interactions with students while working on tasks during the lesson. Described as an important lesson event, "between desk instruction" allows teachers to monitor student learning, engage in meaningful conversations, and employ questioning techniques to scaffold students' thinking.

These practices became particularly significant because they were absent in the online learning environment, as highlighted by Cao et al. (2021). The lack of an equivalent lesson event in the online learning environment made it difficult to monitor student learning during ERT. This emphasises the inherent value of such interactive practice in enhancing the overall quality of teaching and learning experiences.

By interacting with students and implementing these check-ins, the teachers in this present study were able to effectively differentiate the learning for groups or individuals in the face-to-face classroom. By closely observing students, teachers could identify instances of struggle and whether or not the task lacked sufficient challenge. These observations included cues such as students seeking help verbally or displaying non-verbal cues through facial expressions, body language or their approach to the task, indicators that were absent during online learning. In response to these observations, teachers could make immediate decisions, adapt tasks, provide additional materials, or pose question to stimulate critical thinking.

Through these personal classroom interactions, teachers in this study demonstrated a responsiveness to student needs. These interactions served as a means to continually monitor students' learning progress and make any necessary adaptions in the moment. While some planning precedes these interactions, the dynamic nature of the classroom sometimes leads to unexpected situations. Jazby (2018) characterises this ability to improvise in the moment as teachers "think on their feet" (p. 431). In this study, the teachers' accounts indicated their appreciation for these personal interactions and expressed confidence in enacting them effectively in the face-to-face classroom. Monitoring student learning through these personal interactions is considered the most efficient assessment method available to teachers (Cole, 1999).

Examining teachers' accounts of these personal interactions with their students revealed that relationships were developing through these engagements. By facilitating more student choice and agency, teachers were instilling confidence in students, fostering independence and a willingness to take risks in their mathematics learning.

Once again, the teachers reported that they had arranged the classroom environment to facilitate these personal interactions. They aimed for active participation and promoted interactions that built confidence, but also allowed for student choice, and encouraged them to take responsibility for their own learning. This aligns with a discovery by Pianta et al. (2012) which emphasises the classroom as a powerful setting influencing students' development. It also resonates with Walshaw and Anthony (2008) who found that teachers fostering conditions akin to those described by the participants in this study, are able to increase students' sense of agency over their learning and develop important student mathematical dispositions. By establishing the optimal environment, teachers can ensure meaningful interactions and enhance students' learning experiences. Creating the right learning environment can greatly impact the quality of the information gained about students' mathematics learning. This emerged as a consistent finding across the two different learning contexts. Throughout ERT, teachers recounted the strategies they implemented to configure the online learning environment, aiming to reproduce the face-to-face classroom experience and explore avenues for online interaction.

5.3 Comparison Between the Two Learning Contexts

When examining what focused teachers' attention to notice meaningful moments and the teachers' responses to these moments, similarities and differences were identified between the two learning contexts, the online learning environment during ERT and the face-to-face classroom after ERT. During ERT, teachers had to adapt their teaching practices, resulting in some similarities and differences. Upon return to the face-to-face classroom, teachers reported applying what they had learned about their students during ERT to inform and influence their teaching practices.

Due to the limited number of studies comparing these environments in terms of noticing and formative assessment, references to literature in this section are minimal.

5.3.1 *Similarities*

The main similarity between the two learning environments was the teachers focus on engagement. The concept of engagement has gained considerable interest over the years in mathematics due to its association with students' academic achievement levels. Successfully teaching disengaged students proves difficult, given the reduced likelihood of

effective learning. Conversely, engaged students can also serve as valuable indicators of effective teaching as well as provide insights into the students' wellbeing (Attard, 2012).

As mentioned in section 5.1 teachers were focused on engagement in ERT due to concerns about how students would respond to learning online during ERT. Looking for signs of disengagement, teachers wanted to implemented strategies early to re-engage students as quickly as possible. On return to the face-to-face classroom, engagement remained a focus for teachers as everyone settled back in, particularly in mathematics where teachers reported implementing rich tasks with opportunities for collaboration and social interaction.

It cannot be said whether engagement was a focus before entering ERT. However, engagement has been linked to positive outcomes in schools (Fredricks et al., 2004). Monitoring students' engagement levels can also be considered a key aspect of formative assessment. It signifies students' interests, understanding, and active participation in the learning process. In mathematics, observing engagement provides valuable insights into students' attitudes towards problem-solving, perseverance, and willingness to tackle challenging concepts.

5.3.2 *Differences*

There were several notable differences between the two learning environments that impacted teachers' practice. These included types of noticing, teacher-student interactions, methods of feedback, differentiation, the structure of the learning environment, the use of manipulatives, and communication with families.

Due to reduced interaction and the difficulty in observing students' mathematical thinking, teachers' attention may have had a narrower focus online (Sherin & Star, 2011), which led to noticing individual students. Teachers reported observing students exhibiting various learning dispositions in the online environment. These dispositions were surprising to them, which indicated they had not been a focus of their attention prior to ERT. These dispositions became more evident to the participants when teaching in the online environment. In this setting, teachers were using their prior knowledge of their students. Any unexpected or infrequent occurrences, inconsistent with what was known of the students then, captured teachers' attention as potentially meaningful moments. This led to a change in practice as teachers remained focused on noticing students' learning dispositions on return to the face-to-face classroom.

Constructive interactions between teachers and students are considered a key predictor of academic growth (Jerome & Pianta, 2008), highlighting the importance of quality communication during the learning process. ERT posed communication challenges as

physical proximity was lost, making personal communications or whole class discussions harder to implement (Cao et al., 2021). This made it difficult to increase engagement or monitor student learning interactions in the online environment. Instead, teachers and students relied on emails, and online platforms such as Google Classroom or SeeSaw.

The teachers' dedication to creating inventive methods for ongoing interactions with students demonstrated the value they place on these interactions. Although this could be recognised as a similarity, there were distinct variations in how they were conducted in the two environments. In the face-to-face classroom, teachers frequently described spontaneous, in-the-moment classroom interactions with groups of students and individuals, where they could pose questions to assess students' level of understanding, modify tasks, elicit deeper thinking, or simply observe and engage in conversation. In the online environment, teachers invested considerable effort in replicating these interactions virtually. While they could never fully emulate the level of interaction possible in a traditional classroom setting, the use of technology allowed for conversation-like interactions through digital platforms.

One participant in this study chose to use the digital platform during ERT to record their comments and feedback to students verbally in the online environment creating a more conversational atmosphere, which encouraged further student participation. Many students were quite reflective in their responses this way and were more likely to respond to their feedback and act on it.

Feedback, although a practice valued in both environments, was executed differently across the two contexts. Participants demonstrated an appreciation for the importance of providing feedback and actively sought innovative ways to implement this practice in the online setting. Reports indicated that teachers exceeded their schools' expectations during ERT by offering additional feedback to students. In a study by Kalogeropoulos et al. (2021), one participant reported similar, stating that they provided feedback on almost everything, but the timeliness of the feedback was still an issue. In the online environment, teachers felt compelled to provide extra feedback to sustain engagement, address misconceptions, acknowledge achievements, and promote communication. However, the primary challenge reported by teachers in delivering online feedback online was the inevitable delay. The delay highlighted the importance of timely, in-the-moment feedback, an aspect more feasible in the face-to-face classroom. It is worth noting that this study relied on teacher recall rather than observations, which could have provided more detailed insights into the timing, recipients, and effectiveness of the feedback in both contexts.

Another practice that differed greatly between the two contexts was differentiation. Teachers reported implementing open, rich tasks in the classroom, feeling adept at

assessing students' understanding in-the-moment and making necessary adjustments throughout lessons. However, these practices proved challenging to reproduce in the online environment. To differentiate online, teachers opted to provide a variety of tasks in order to ensure students could access the learning. While acknowledging the considerable increase in workload and the change from their typical face-to-face teaching practices, it highlighted the value teachers place on students' engagement and providing the right level of challenge for each student.

The learning environment plays a pivotal role in providing opportunities to notice and respond to meaningful moments in mathematics learning (see Section 5.12, 5.24 and 5.25). The primary difference between the learning environments was the lack of social interaction and collaborative opportunities in the online environment, which were more easily facilitated in the traditional classroom setting. Analysis of participants' accounts of noticing and responding in both contexts revealed that the structure of the environment was a critical factor for effective observations of students' mathematical learning, similar to findings from Jazby (2020). Strategies for structuring the learning environment varied between contexts. During ERT, teacher implemented synchronous learning opportunities, one-on-one sessions, and increased their contact with families. One return to the face-to-face classroom teachers were using more open, rich tasks and collaborative learning opportunities. In both contexts, teachers regularly reflected on and adjusted the environment as needed to meet students' needs.

Creating an optimal learning environment involved incorporating student choice, an important aspect highlighted in this study. While student-centred learning has been extensively documented (Overby, 2011; Vale et al., 2010), the interesting finding in the current study was how teachers implemented student choice online during ERT. In the online learning environment, this was achieved by allowing selection of task or strategies for solving tasks and providing personalised learning opportunities. Offering student choice became a key strategy teachers reported using to engage students displaying signs of disengagement during ERT. Students who were reported to have thrived in the online environment may have experienced success due to increased autonomy at home. They were free to choose when to start their tasks, determine how long they wanted to work on a task, and were aware of the option to seek assistance or participate in focus groups if needed. Back in the face-to-face classroom, offering student choice involved aligning mathematical tasks with student interests, and implementing flexible student groupings.

Other noteworthy differences emerged between the two environments. For example, the teachers discussed using manipulatives in their mathematics lessons in the face-to-face mathematics classroom. Reports indicated that the online environment was perceived as

less hands-on, making it challenging to teach certain concepts without the materials typically available in the face-to-face classroom. Although not a perfect substitute for classroom mathematical manipulatives, an opportunity may have been overlooked to utilise materials that can be found in the student's home environment, for example, toys, cutlery, pegs and other household items. However, it is acknowledged that not all students may have had access to such items.

Finally, teachers noted increased communication with families in the online learning environment. Families emerged as invaluable sources of information, particularly when teachers could not physically observe the students. Not only were families taking on some of the roles of the teacher at home, but they also offered insights into students' wellbeing, their engagement with online learning and the appropriateness of tasks in terms of the level of difficulty. This information proved instrumental in aiding teachers' planning and guiding their decision-making on when and how to intervene. It also proved beneficial in tailoring personalised learning opportunities for these students. Upon return to the face-to-face classroom after ERT, there were fewer reports of communication with families. It is unclear whether this decrease was because teachers did not report such communication or because there was genuinely less need for it once teachers could observe the students in real-time in the classroom.

5.4 Summary

In this chapter, the key findings with regard to the three research questions were discussed in relation to the literature underpinning the study.

This study aimed to underscore the critical role of teacher noticing and responsive practices as informal formative assessment tools in mathematics education, offering a nuanced understanding of how these practices function in different learning environments. Classroom observations, a cornerstone of formative assessment, enable teachers to attend to students' mathematical thinking, interpret their understanding, and make informed decisions to support their learning. However, during Emergency Remote Teaching (ERT), limited interaction opportunities curtailed the spontaneity of in-the-moment noticing and responsiveness, emphasising the irreplaceable value of daily classroom practices for student engagement and learning.

Key findings highlight two distinct types of noticing: individualised noticing in the online environment and noticing events in the face-to-face classroom. In the online context, individualised noticing provided teachers with insights into specific students' needs, prompting targeted interventions to enhance their mathematical learning. Conversely, noticing events in the classroom encouraged broader reflections on teaching practices, often

resulting in strategies that benefited multiple students. This distinction between noticing types represents a novel contribution to the field, offering new perspectives on how noticing functions across learning contexts.

Teachers demonstrated adaptability in structuring learning environments to support noticing and responsiveness, showcasing the importance of intentional design in fostering effective learning opportunities. Previous research by Pianta et al. (2012) and Walshaw and Anthony (2008) and discussed in the context of teacher noticing by Jazby (2016) and Van Es and Sherin (2021), has highlight the importance of the learning environment in noticing and responding. Learning environments that encourage student engagement and confidence not only promote active learning but also provide teachers with rich evidence of students' cognitive processes. These flexible, responsive settings are vital for meeting diverse learning needs and maximising the impact of formative assessment practices. The study's findings highlight the need for further research into how various learning environments influence teacher noticing and how the formative assessment information derived from noticing is utilised to enhance mathematics learning.

Another notable finding relates to the role of family communication during ERT. Teachers reported leveraging parent insights to compensate for reduced visibility into students' learning during online instruction. These strengthened home-school relationships provided valuable, holistic perspectives on students, encompassing their academic, emotional, and social needs. While parental involvement during ERT has been widely discussed, this study identifies a unique use of parental input as a tool for teacher noticing, a finding not previously reported in the literature.

Overall, this research sheds light on how teachers navigated the challenges and opportunities of teaching during ERT and transitioned their practices back to the face-to-face classroom. By focusing on engagement, structured environments, and collaborative relationships with families, teachers effectively adapted to changing circumstances, underscoring the critical interplay between noticing, responsiveness, and the design of supportive learning environments in mathematics education. These insights highlight important directions for future research, particularly in exploring the long-term impacts of these practices on student learning and teacher professional development.

In the next chapter, a conclusion to the study is presented. This includes an overview of the research with a summary of the key findings, limitations of the research, implications for practice and suggestions for further research.

Chapter 6: Conclusion

In this concluding chapter, an overview of the study will be provided by revisiting the research questions and summarising the key findings. Limitations of the study will be addressed, followed by implications and recommendations for practice and further research. Finally, suggestions for potential future research directions will be provided.

6.1 Overview of the Research

This study sought to investigate teachers' reflections of noticing as a critical action of informal mathematics assessment from the teacher's perspective and identify what teachers' notice that is meaningful for mathematics learning. It examined how teachers gathered evidence through observing meaningful moments and how this information was used to enhance student learning. A comparison was made between two different learning contexts that prevailed across the duration of the study: the online environment (during ERT) and the face-to-face classroom (after ERT).

While not initially planned, my study coincided with the COVID-19 pandemic, presenting an unexpected yet valuable opportunity to conduct research in an unprecedented context. The temporary shift to online learning for all students resulted in changes to teaching and learning. Teachers had limited time to transfer their teaching practices to the online environment, which impacted students' mathematical experiences. This unexpected opportunity led to Research Question 3, comparing teachers' reflections of noticing in online settings to teachers' regular face-to-face classrooms.

This study sought to answer the following research questions:

1. What focuses primary teachers' attention to notice moments meaningful to mathematical learning?
2. How do teachers respond to what they notice?
3. Regarding mathematics learning, how does what teachers notice and respond to in the online context compare to the face-to-face context?

Employing a general qualitative research approach, this study conducted semi-structured interviews on two separate occasions in 2020. Interviews were conducted online via Zoom with eight teacher participants, the first during ERT in Term 3 and the second, when teachers and students had returned to the physical classroom early in Term 4. The interviews sought to understand teachers noticing practices whilst teaching mathematics remotely and face-to-face in the classroom.

Each interview was structured around four main questions. These key questions guided the conversation focusing on a recent highlight, any changes made to instruction, tasks, or teaching practices, a memorable moment from a recent mathematics lesson or involving a student, and something noteworthy that was surprising or interesting (see Appendix D). The wording of these questions differed slightly depending on the specific interview.

The two interviews were pre-planned at the outset of the study, with each of the four questions matched to its equivalent across the two interviews. Two noticing frameworks, Van Es and Sherin's (2002) *Learning to Notice* framework and Jacobs et al.'s (2010) *Professional Noticing of Children's Mathematical Thinking*, guided the research process.

After transcribing the interviews, the data were coded. The process started with complete coding to identify all information relevant to the research questions. Since ERT was an entirely new situation, an inductive approach was employed to complete the initial level of coding, followed by multiple levels of coding through different lenses. Thematic analysis was used to identify themes and patterns within the data in relation to the research questions. Three main themes emerged from the data: Adaptions to mathematical instruction: Teacher responsiveness, Student participation and dispositions, and Communication with families.

A summary of the key findings follows.

6.2 Summary of Key Findings

In the previous chapter, the main findings from each research question were discussed. In the section that follows, a broader view of the key findings will be presented with links made to the research questions.

6.2.1 *Teachers' Focused Attention and Connections With Students*

During Emergency Remote Teaching (ERT), student engagement emerged as a central focus for teachers, reflecting the social constructivist emphasis on interaction and connection in the learning process. Teachers closely monitored fluctuations in engagement, noting both unexpected increases and decreases. The novelty of ERT, combined with the unique circumstances of lockdown, introduced uncertainties about how students would adapt to online learning. Teachers relied on their pre-existing knowledge of students from prior face-to-face interactions, using this understanding to guide their observations and shape their responses. These early connections with students proved critical in fostering effective

noticing and informing interventions, underscoring the value of relational foundations in both online and in-person settings.

In the online environment, the absence of the physical classroom's dynamic interactions narrowed the scope of teacher noticing. Teachers were unable to observe rich, spontaneous mathematical discussions but instead concentrated on observable individual behaviours. This narrowed focus deepened their understanding of students' dispositions, attitudes, and approaches to learning. Teachers noticed that some students became more confident, independent, and responsible during online learning. These observations provided insights into how students developed as autonomous learners, a key principle of social constructivism where learners are seen as active participants in constructing their knowledge through interaction and reflection.

The study revealed that individualised noticing during ERT marked a shift from teaching to learning (Leahy et al., 2005). Teachers adapted their practices to maintain and strengthen connections with students, leveraging communication with families to gain holistic insights into students' experiences. These family-teacher collaborations extended the reach of noticing beyond the classroom, providing a more comprehensive understanding of students' academic and personal development.

Post-ERT, in the face-to-face classroom, teachers' noticing evolved to include both individualised and event-focused observations. For instance, during rich mathematical tasks, teachers listened to group discussions, questioned students, and reflected on their practices to enhance collective learning opportunities. These moments provided teachers with a broader understanding of how students engage with mathematical concepts collaboratively, reinforcing the importance of interaction as a catalyst for learning.

Noticing individual students online and significant moments in the classroom offered teachers a dual lens to understand students' mathematical learning holistically. This dual approach allowed teachers to focus on not only the content of learning but also the processes through which students engage and grow as learners. These findings deepen our understanding of teacher noticing by highlighting its adaptability across contexts and its centrality to fostering meaningful connections and promoting social constructivist practices in mathematics education.

6.2.2 *Responsive Teaching and the Learning Environments*

The findings of this study highlight the adaptability of teachers as they shifted their approaches to accommodate the challenges of Emergency Remote Teaching (ERT). In face-to-face classrooms, frequent social interactions and collaborative learning create

natural opportunities for informal assessments of students' mathematics learning. These interactions allow teachers to observe, interpret, and respond to students' mathematical thinking in real-time. However, during ERT, teachers faced significant obstacles, including technological barriers, communication delays, and reduced visibility into students' learning processes.

Despite these challenges, teachers adapted their focus to individual students' dispositions and approaches to learning. The constraints of the online environment offered a new lens through which teachers observed previously unseen learning behaviours. This deeper understanding of students' positive dispositions empowered teachers to design more personalised learning experiences during ERT. These insights continued to inform their practice upon returning to the face-to-face classroom, where teachers recognised the importance of fostering and sustaining these dispositions to support students' overall learning processes.

The learning environments created by teachers reflect a social constructivist emphasis on interaction, autonomy, and active participation. Using Van Es and Sherin's (2021) Learning to Notice framework, teachers shaped these environments through strategies like small focus groups and offering students more choice in their learning. These strategies were pivotal in fostering engagement and facilitating rich mathematical discussions. By centring the learning environment around the students, teachers enabled more meaningful interactions, enhancing their ability to notice students' thinking and adapt their instruction accordingly.

A significant aspect of these student-centred environments was the integration of choice, which empowered students to take ownership of their learning. In both online and face-to-face settings, students were given options regarding tasks, materials, collaboration groups, and even the pace of their work. This autonomy not only increased engagement but also offered teachers valuable opportunities to observe how students navigated these choices, providing insights into their cognitive and emotional approaches to learning mathematics.

The autonomy experienced by students during ERT, choosing when and how to engage with tasks, was particularly beneficial for some, as it aligned with their preferred learning styles. Teachers leveraged this information to design more flexible and responsive learning experiences that catered to individual needs. These personalised approaches, underscore the social constructivist view that learning is a collaborative, interactive process, with students actively constructing knowledge through meaningful engagement in the learning environment.

In sum, this study advances our understanding of teacher noticing by demonstrating its adaptability across learning contexts and its role in shaping environments that support meaningful interactions and student autonomy. These findings underscore the significance of intentional, student-centred approaches in promoting mathematical understanding and emphasise the critical influence of the learning environment on effective teacher noticing.

6.2.3 *Comparison Between the Two Contexts*

This study offers valuable insights into the evolving nature of teacher noticing and its connection to a social constructivist view of teaching. Student engagement emerged as a consistent focal point in both Emergency Remote Teaching (ERT) and face-to-face classrooms, although its emphasis prior to ERT remains uncertain. The unexpected positive learning behaviours observed during ERT suggest that these behaviours had not been a significant focus before, highlighting how the shift in learning environments influenced teachers' attention and practices. Importantly, teachers reported continuing to notice and foster these behaviours upon returning to face-to-face teaching, indicating a lasting change in their professional practice.

A critical difference between the two environments was the level of social interaction. Online learning lacked the spontaneous, dynamic collaboration typical of face-to-face classrooms, despite teachers' efforts to replicate such interactions. Upon returning to the classroom, teachers intentionally created opportunities for collaboration and interaction, potentially as a response to the limited social exchanges experienced during ERT. This aligns with social constructivist principles, which emphasise the centrality of social interactions in the co-construction of knowledge. Teachers deliberate efforts to foster collaboration after ERT suggest an enhanced appreciation for the role of social dynamics in mathematical learning.

ERT also revealed unique opportunities for individualised noticing. The online environment, characterised by reduced classroom visibility, prompted teachers to focus more narrowly on individual students. This allowed them to notice specific dispositions and learning behaviours that might have gone unnoticed in a traditional classroom setting. For some students, the private, asynchronous nature of online communication provided a more comfortable space for interaction, leading to increased confidence and engagement. Teachers leveraged these insights to create personalised learning opportunities, tailoring instruction to students' individual needs.

Additionally, communication with families became a pivotal aspect of noticing during ERT. With limited direct interactions, teachers relied on families to act as intermediaries, providing valuable insights into students' learning experiences. This strengthened home-

school connections and broadened teachers' understanding of their students, extending the social constructivist perspective to include familial contributions to the learning process.

The study also highlights differences in the outcomes of noticing in the two environments. While individualised noticing during ERT often led to actions that enhanced individual students' learning, noticing in face-to-face classrooms typically resulted in reflections on teaching practices that benefited the entire class. This dual approach to noticing, combining individualised insights with broader classroom observations, has the potential to create a more holistic understanding of students as learners. Future research could explore how to integrate these practices into daily classroom interactions, fostering a balanced approach that enhances both individual and collective mathematical learning experiences.

Overall, these findings deepen our understanding of teacher noticing as a dynamic process influenced by the learning environment. They also reaffirm the social constructivist view that meaningful learning occurs through interactions, not only within the classroom but also within the broader social context that includes families and individualised student-teacher exchanges.

6.3 Limitations of the Study

While the key findings reported here contribute to research on informal formative assessment and noticing, they should be considered in the light of some limitations. These will be addressed below.

6.3.1 *Generalisability*

This study had a small sample size, comprising only eight primary teachers from seven schools within Melbourne, Victoria. While this study offers valuable insights into teaching practices within the specified contexts, with only participants from the primary sector, there are no views of secondary or early childhood teachers. Furthermore, teacher participants were all teaching within Years 3 to 6; this factor, coupled with their years of teaching experience, may limit the study's ability to draw comprehensive comparisons of the approaches and challenges present in primary education. As such, the findings cannot be extrapolated to broader educational contexts beyond the specific parameters of the study.

6.3.2 *Timing of Study*

Research was conducted amidst the unprecedented circumstances of the COVID-19 pandemic, during which educators and students navigated the uncharted territory of ERT. The absence of classroom observation, a traditional cornerstone of educational research,

represents a significant constraint, depriving the study of firsthand insights into teaching practices and student interactions within physical learning environments. In hindsight, it could have been possible to observe lessons online during ERT. However, given that researchers were barred from visiting classrooms for a considerable duration following the transition to the physical classroom due to social distancing regulations, it was not possible for classroom observations to be conducted for comparison.

Although classroom observations were not feasible due to the constraints of the pandemic, each participant participated in two interviews. These interviews provided an opportunity for teachers to reflect on their experiences during ERT, share anecdotes about their students, and discuss specific moments that stood out. Teachers eagerly recounted meaningful experiences they felt were important to share with the researcher.

As the first interview in this study was conducted while teachers and students were in ERT, there is no preceding data available from before ERT. The data collected from the face-to-face classroom setting occurred post the COVID-19 pandemic. Therefore, it remains uncertain whether these data align with, or is different from, what could have been collected prior to ERT. For example, the timing of data collection in this study imposes limitations on determining whether the teachers' emphasis on engagement in the classroom existed before ERT. Although there was a strong focus on engagement on return to the classroom post-ERT, it is plausible that this emphasis stemmed from efforts to re-engage students in the face-to-face classroom environment following an extended period of ERT.

6.3.3 *Teacher Self-Reported Data*

While teacher's self-reported data is inherently subjective, these insights offer a glimpse into educators' perceptions, experiences, and adaptations during online learning. It is important to note that reliance on self-reported data necessitates cautious interpretation and acknowledges the potential for bias and subjective interpretation inherent in such accounts. However, it is believed certain conditions were met to conclude that the teachers' responses could be considered trustworthy and authentic findings. The interview questions were carefully constructed and asked clearly and unambiguously; the teachers responded thoughtfully and shared stories that directly related to the questions asked.

6.4 Implications and Recommendations for Practice

This study aimed to highlight teacher noticing as an effective form of informal formative assessment in the mathematics classroom. The most significant discovery revealed teachers' use of their connections with students to understand them more as individual learners, shifting the emphasis from "teaching" to "learning". Consequently, the

implications are linked to implementing this approach to noticing into everyday classroom practice, prioritising establishing the optimal learning environment.

6.4.1 *Understanding Students as Learners of Mathematics*

Teachers shifted their focus from simply noticing the mathematical content and students' capabilities to noticing the students as individuals and understanding them as learners of mathematics. Kazemi et al. (2016) reported that classroom interactions provide teachers with opportunities to elicit students' thinking and gain a better understanding of their students as mathematicians. This shift in attention from teaching to learning provides teachers with opportunities to gain crucial information about their students, which could then be used to provide immediate assistance, give timely feedback, challenge thinking and inform future planning.

I recommend a holistic approach to noticing in the mathematics classroom, individualised noticing that can impact that student's mathematics learning, as well as noticing of events that can lead to changes in practice, potentially enhancing the mathematics learning of all students. In addition to eliciting students' thinking, focusing on key elements such as student engagement and learning behaviours provides teachers with important information meaningful to students' mathematics learning. This comprehensive perspective facilitates more effective noticing, enabling the creation of personalised and meaningful learning opportunities in mathematics.

6.4.2 *Structuring the Learning Environment*

Teachers enthusiastically embraced the social dynamics of the classroom, fostering extensive collaboration and creating opportunities for rich interactions where they noticed more moments meaningful to students' mathematics learning. The absence of this social aspect of the classroom during ERT served as an important reminder to teachers of its importance in facilitating students' learning.

Intentionally structuring the learning environment or shaping the events that occur within it ensures ample opportunities for insightful observation. In this study, teachers created environments that not only promoted social interaction, but prioritised student-centredness, fostering independence and engagement. In these conditions, students were actively involved, appropriately challenged, and nurtured in their self-confidence as mathematics learners, creating an optimal environment for teachers to monitor student learning.

I recommend that teachers consider the classroom setting when employing teacher noticing as an informal formative assessment practice. Teachers need to employ strategies,

structuring the learning environment to effectively focus their attention on noticing and responding to meaningful moments that will allow them to gather vital evidence about students' mathematics learning.

6.4.3 *Home-School Connections*

Teachers valued the connections they had with their students and utilised the families to maintain those connections and learn more about their students, even in the absence of direct physical interaction.

During ERT, communication with families increased as teachers sought to compensate for the lack of in-person contact and the consequent absence of certain student-related information typically available in the physical classroom. Families played a crucial role in providing teachers with pertinent details about their students' wellbeing and additional insights.

I recommend that teachers continue to nurture strong home-school connections through regular communication with their students' families. Families are the child's first educators and offer a unique perspective that may not always be apparent to teachers within the classroom setting. Working in partnership with families fosters strong home-school connections than can enrich student learning experiences.

6.5 Recommendations for Future Research

There is much can be learned regarding the impact of COVID-19 on education. Online learning while convenient and accessible, inherently lacks the immediacy and spontaneity of traditional classrooms due to the physical separation of students and teachers. Reflecting on our experience in ERT, several questions arise important to the future of education: How did the online learning environment change teaching practices? What effects did online learning have on student achievement? While this study found that teachers' experience in ERT influenced their subsequent teaching practices, it remains uncertain whether some of their reports about their face-to-face noticing were a direct consequence of their experience teaching online. Given the context of the study, it cannot be determined whether teachers reported teaching practices in the face-to-face classroom were reflective of their teaching practices prior to ERT.

Understanding the interplay between teacher-student interactions, the learning environment, and teacher noticing has the potential to enhance the effectiveness of informal formative assessment, providing deeper insights into student learning. Below are some suggested directions for future research.

6.5.1 *Teacher-Student Connections*

Previous research has highlighted that relationships play a key role in teacher responsiveness and advancing student's thinking (Jacobs & Empson, 2016; Kazemi et al., 2016). In this study, teachers' connections with their students provided valuable background knowledge for teaching remotely during ERT and enabled teachers to broaden their focus from solely noticing mathematical content and students' capabilities to noticing many students more as individuals.

Further research could explore how teachers' connections with students influence the effective use of informal formal assessment in daily classroom interactions. A longitudinal study could investigate how the information gained through informal formative assessment practices in the mathematics classroom evolves over a school year as teachers' connections with their students develop.

6.5.2 *Exploring Teacher Noticing in Various Contexts*

Teachers in this study used the learning environment strategically to focus their attention, influencing what they noticed and how they responded. They described actively shaping the environment, implementing strategies to maximise engagement in their mathematics lessons, empowering students to take ownership of their learning, and facilitating rich discussions and interactions.

This study employed two noticing frameworks: *Professional Noticing of Children's Mathematical Thinking* by Jacobs et al. (2010) and the *Learning to Notice* framework from Van Es and Sherin (2002). Of particular note was the emphasis on the *shaping* aspect within Van Es and Sherin (2021) expanded framework, which raised the question – how important is the learning environment for effective noticing?

Future research could investigate how teacher noticing varies across diverse mathematics classroom environments and the resulting impact on observed meaningful moments. By examining different learning environments and their influence on teacher noticing and the efficacy of informal formative assessment, researchers could identify the optimal conditions for enhancing teacher-student interactions. This research could empower teachers to gather valuable evidence of student learning more effectively.

Future research could also consider how the structure of the learning environment can be integrated into teacher noticing frameworks. A framework for noticing involves being aware and responding to key elements and events, and its effectiveness may depend on the set up of the learning environment. Additionally, the structure of the learning environment may impact the quality of the information gained through moments noticed. Identifying the

aspects that create a positive, interactive classroom learning environment could impact the *how* and *what* teachers notice.

Due to the limitation imposed by the COVID-19 pandemic, this study faced constraints in data collection. Observing classrooms directly would allow researchers the opportunity to capture real-time classroom dynamics. Video-recording lessons would allow researchers to closely examine different aspects of the lesson, identifying patterns across different learning environments and their effects on teacher noticing.

6.5.3 *Teacher Responses to Enhance Student Learning*

Teachers' responses to what they notice during mathematics lessons can greatly influence student learning. This study revealed that when teachers focused on noticing individual students, there was potential for targeted improvements in those students' learning. In contrast, when teachers reflected on specific events noticed during a lesson, there was potential for broader enhancements that could improve the mathematical learning experiences of all students.

Further research could explore how we can give students more individualised attention in traditional classroom settings. Exploring the differences between individualised noticing and noticing events during daily classroom interactions, can provide insights into their respective impacts on learning. One proposed approach involves examining how these forms of noticing affect students' mathematical learning from the students' perspectives.

One particular action the teachers employed was to offer more student choice. By incorporating more student voice and choice in their mathematics learning during ERT, teachers reported increased student engagement and empowerment, leading to a deeper understanding of their students as learners of mathematics.

Further research could investigate the ways in which teachers offer student choice in the mathematics classroom and the impact this has on student learning. Additionally, the perceptions of offering student choice from both the teachers' and the students' perspectives could also be explored.

In summary, teachers reflected that noticing students' mathematical thinking was easier to implement in a face-to-face classroom, where real-time interactions can be facilitated. However, various contextual factors such as the arrival of a new student or implementing a new curriculum, can influence what and how teachers notice, making it difficult to prescribe a singular approach to enact this practice even in the traditional classroom. Our experiences in ERT highlighted the importance of our daily classroom

interactions for observing and gathering evidence of students learning, emphasising that this is an avenue worth further exploration.

6.6 Concluding Remarks

This study highlights the important role of teacher noticing as an informal formative assessment practice in primary mathematics education. By effectively utilising this practice, teachers can gain valuable insights into students' learning. Focused attention on individual students reveals insights into student engagement and positive learning behaviours, underscoring the importance of individualised noticing to understand how students learn and develop as learners of mathematics. Structuring the learning environment emerged as a key factor in creating opportunities for noticing and fostering effective teacher-student interactions where evidence of learning can be gained and used to enhance students' mathematics learning. Teachers implemented two types of noticing: individualised noticing and noticing of meaningful events, both which had the potential to impact to student learning. By utilising both forms, teachers can adopt a more holistic approach to teacher noticing, focusing on understanding their students as learners of mathematics and enhancing their mathematical experiences.

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Appendices

Appendix A: Ethics Approval

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project ID: 23609
Project Title: An investigation into the cues that lead teachers to noticing moments of significance in the primary mathematics classroom.
Chief Investigator: Dr Jill Cheeseman
Approval Date: 05/06/2020
Expiry Date: 05/06/2025

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MUHREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Mrs Anita Green

List of approved documents:

Document Type	File Name	Date	Version
Supporting Documentation	Email Invite	12/05/2020	1
Explanatory Statement	Explanatory Statement	12/05/2020	1
Consent Form	Principal consent form	12/05/2020	1
Consent Form	consent form-teacher	12/05/2020	1
Consent Form	consent form - parent and child	12/05/2020	1
Supporting Documentation	Possible Interview Questions	12/05/2020	1
Supporting Documentation	Explanatory statement - teachers	05/06/2020	2
Supporting Documentation	Explanatory statement - parents	05/06/2020	2
Supporting Documentation	Explanatory statement - child	05/06/2020	2
Explanatory Statement	Explanatory Statement	05/06/2020	2

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Appendix B: Participant Email & Explanatory Statement

MONASH University

Participant Email

Dear _____,

My name is Anita Green and I am a PhD student from Monash University. I am currently undertaking a research project which aims to document ways in which teachers recognise that an important moment has arisen in their mathematics classroom. Teachers notice what students say and do in mathematics lessons as part of their work and noticing is a natural, everyday act for a teacher. Yet little is known about how teachers choose what to notice, and how they make sense of moments that have the potential to be pedagogically relevant.

The research will involve the observation and video recording of two regular mathematics lessons of four primary classroom teachers. Moments of interest will be identified and discussed with the teacher in an interview lasting no longer than 30-minutes. The interviews will be audio recorded and excerpts of the video recording may be used during these interviews to prompt discussion. Observed lessons and interviews will be arranged at times to suit the school, teachers and students.

As a school that has primary teachers with a strong interest in mathematics, problem solving and assessment, your school would be a great choice as participating school in this research project.

If you would like any further information please do not hesitate to ask.

I look forward to hearing from you.

Kind regards,

Anita Green

MONASH University

Explanatory Statement—Teachers

Project ID: 23609

Project title: An investigation into the cues that lead teachers to noticing moments of significance in the primary mathematics classroom.

Chief Investigator	Student Researcher
Dr Jill Cheeseman	Ms Anita Green
Faculty of Education Monash University	Faculty of Education Monash University
+61 3 9904 4246	0413 774 944
jill.cheeseman@monash.edu	anita.green1@monash.edu

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

What does the research involve?

This project aims to find out what are the cues that signal to teachers that there is a noticeable moment. Once these cues are identified I aim to establish which cues led to moments of the greatest mathematical significance. The act of noticing for teachers is a natural, everyday act for a teacher. Teachers spend half to one-third of each lesson observing the classroom and choosing what to notice, and how to make sense of moments that are pedagogically relevant.

The research will include the observation and video recording of two 1-hour mathematics lessons. The researcher will be present as an observer of the lesson and the teacher will be required to wear the video camera (GoPro) to capture the lesson from the teacher's perspective. Moments of interest with be what the teacher notices and attends to during this lesson.

The next part of the research is a 30-minute one-on-one interview where you will be asked to discuss and reflect on the moments that were noticed during this lesson. The discussions will focus what was noticed, what led you to noticing this moment, what information you

gained from noticing this moment and what you did with this information. Excerpts from the video recording can be used during these interviews to enhance the discussion.

These interviews will be audio recorded.

The aim is to conduct these interviews as soon after the lesson as possibly. These lessons and interviews can be timetabled to be conducted at a time that suits you and your class.

Why were you chosen for this research?

As a primary teacher with an interest in mathematics you were seen as a possible participant for this research project. Other factors include:

- teachers who use open ended, problem solving tasks regularly to elicit student thinking
- teachers confident in assessing in-the-moment
- teachers who use observation as a regular assessment tool

Contact information has been obtained through previous Numeracy Networks/the reSolve network/word of mouth.

Consenting to participate in the project and withdrawing from the research

Participation in any research project is voluntary. In order to consent to be involved in this research project you need to read the Explanatory Statement and return the Consent form. Your consent will be sought once the principal at your school has provided consent. We will seek the informed consent of the other teachers, and parents/guardians of students in one of your classes once you have provided consent and we have met and discussed the other potential participants.

If you do not wish to take part you are not obliged to sign the Consent form.

If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. Any information obtained from your school to date will not be used and will be destroyed.

Your decision whether to take part or not, or to take part and then withdraw, will not affect your relationship with the researchers or Monash University.

Before you make your decision, a member of the research team will be available to answer any questions you have about the research project. You can ask for any information you want. Sign the Consent Form only after you have had a chance to ask your questions and have received satisfactory answers.

If you decide to withdraw from this project, please notify the Chief Investigator, Jill Cheeseman, or complete and return the Revocation of Consent Form attached.

Possible benefits and risks to participants

This study directly benefits you, your students and the school community. Previous research has highlighted the importance of teacher noticing in the mathematics classroom. This research project will give teachers the opportunity to focus on their own teaching practice with emphasis on the moments they notice in their own mathematics lessons. This is professional development that can be significant for the PPDP process.

In a time where assessment can be very data driven participating in this research project is an opportunity to highlight to school communities the in-the-moment assessment that teachers do every day and the benefits of this for both teachers and students.

The only minor risks that are foreseen for this research project are time and possibly the observations. As a part of this research project interviews will be conducted after each lesson observed/videoed. To try and minimize the inconvenience teachers will have the opportunity to choose the days the lessons/interviews are conducted and the interviews will be capped at 30 mins. For some teachers being observed can be daunting. However, for this reason teachers can make the choice once they aware of the full extent of the project as to whether they want to be a participant. The researcher aims to be a quiet observer in the classroom so as to allow the teacher and the students to work through the lesson as normal. For some teachers reflecting on their own teaching practice can cause a little discomfort. Every effort will be made to develop a working rapport with each participant and make them feel as comfortable as possible to openly chat during interviews.

Confidentiality

Teacher and students' identity in the video-recordings cannot be masked, and would be recognisable, but will only be used in interviews with the student's classroom teacher. No student whose parents/guardians have not granted consent will be video recorded.

Any transcripts of lessons or interviews with are de-identified using pseudonyms as each is generated.

Reports and publications such as journal articles and conference papers from the analysis of the audio or video will use pseudonyms to protect the identity of the school, teachers and students. You will be invited to view any video or images to be shared, or shown for use in education purposes with the education community to ensure there is no embarrassing footage or images.

Storage of data

Data collected will be stored in accordance with Monash University regulations. Hard copy raw data such as written student work samples and teacher resources and materials will be stored in a locked cabinet by the researcher and destroyed after five (5) years. Soft copy raw data that is, the audio and video-recordings and transcripts of these recordings will be stored in a password protected Monash University cloud site. These data will be deleted after 5 years.

Results

Results of the study will be published in academic and teacher journals and presented at academic and teacher conferences. A final report of the project will be provided to your school and the Department of Education and Training.

Complaints

Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics Committee (MUHREC):

Executive Officer

Monash University Human Research Ethics Committee (MUHREC)
Room 111,
Chancellery Building D,
26 Sports Walk, Clayton Campus Research Office
Monash University VIC 3800
Tel: +61 3 9905 2052 Email: muhrec@monash.edu Fax: +61 3 9905 3831

Thank you,
Jill Cheeseman

Appendix C: Consent Form—Teachers

MONASH University

Consent Form—Teachers

Project ID: 23609

Project title: An investigation into the cues that lead teachers to noticing moments of significance in the primary mathematics classroom.

Chief Investigator	**Student Researcher**
Dr Jill Cheeseman	Ms Anita Green
Faculty of Education Monash University	Faculty of Education Monash University
+61 3 9904 4246	0413 774 944
jill.cheeseman@monash.edu	anita.green1@monash.edu

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to:	**Yes**	**No**
Participating in 2 x 30 min one-on-one Zoom interview with the researcher	☐	☐
Having these Zoom interviews recorded	☐	☐

Name: _____

Signature:_____

Name of School:_____

Appendix D: Interview Questions

Interview Questions (During remote learning)

- What has been one of the biggest highlights for you during remote learning? Who was involved?
- What changes to your teaching/tasks/delivery based on what you have observed of the students during remote learning?
- Tell me about something you have noticed about a student (or students) during remote learning.
- How has a student surprised you during remote learning?
- Is there anything else you would like to share with me?

Interview Questions (After remote learning)

- What was a highlight for you today (or recently)? Who was involved?
- Have you noticed any changes since returning to school?
- Tell me about a recent maths lesson.
- Tell me about something you have noticed about a student (or students) that was significant.
- Is there anything else you would like to share with me?

Appendix E: Example of Transcribed Interview

Interview 1—with Jennifer

Interview (Draft Format):

AG_Jennifer

Participants:

Q: Interviewer

A: Participant

(Note: Gaps in transcript, due to being an online recording, due to background noise, and due to participants being inaudible at times.)

Q: Awesome, so we'll get started, since I know you have to go.

A: Yeah, yep.

Q: No, that's okay.

A: Sorry, I've got to go pick something up and they're leaving, they can't – like I can't be there after five, so that's alright.

00:20

Q: No, that's all good. So, what's remote learning been like at your school?

A: So, like the format of it?

Q: Yeah.

A: Yeah, so we've actually, we just changed it this term, and then it was announced that we're going back, so we've rejigged our whole thing, and then, now we don't – not going to be using it. So, … most of the time, what we did is we had live – we didn't do much live teaching, we had like, I think it was half an hour groups with, like just with one group per day, and the rest of it was all in video form. And so, we recorded, we had – so, we had maths and spelling, writing, reading, and for maths we had three differentiated groups, and each group had their own instructional video-

Q: Right. It's a lot-

A: With an activity – it was a lot, yeah. There was a lot of videos. There was a video for every single subject area for every single day, and then for writing there was, even – we split them into two groups … (Inaudible) so, there was two, often two videos per – right, it was crazy. But – and then we met with – like, we only, actually, we met with the students once a week for their small group, and then we did a welcome message every morning for them on See-Saw, and we had to comment. We were told we only had to comment on one thing each day, but which was really generous, but we didn't, like just because we did, probably, commented on, I would say, you know, 75 percent of things, just because like if you see a child got it wrong, you're not going to ignore it.

Q: That's right.

A: You need to correct the misconceptions. And also, if you've got a student who's disengaged, like you want to keep pumping them up. So, yeah, so that was the way we were doing it. And now we switched it to, like two hours of live teaching.

Q: Yep.

A: And then, like whole class – like the format was whole class, small group, and then reflection whole class for writing and reading, and then they did maths with an instructional video from a teacher, from one of us, in three differentiated groups, again- … (Talking over each other) and spelling. So, yeah, it was – yeah, it was full-on. It was going to be – it's much better this way. We've done it for one week, and now we have to go back, so yeah, but, oh, well