Maths Talk

The Voices of Teachers in Irish Classrooms

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Declaration:

I hereby declare that this dissertation is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly. This work has not been submitted previously at this or any other educational institution. The work was done under the guidance of Breed Murphy at the Marino Institute of Education, Dublin. I agree that the Library may lend or copy this dissertation upon request.

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Abstract

A new Primary Mathematics Curriculum is due to be operational in Irish classrooms in September 2024. One of the five key pedagogies of this new curriculum is Maths Talk, yet little is known about how teachers can be supported to implement in their classrooms. This qualitative case study was situated in the context of the roll-out of the New Primary Mathematics Curriculum. It examined what supports teachers perceived they had or needed to implement Maths Talk in their classrooms. It. Four mathematics lessons were observed in first and second class. These observations were analysed thematically and that analysis contributed to the structure of a focus group, together with themes that emerged from a review of literature. Particular attention was paid to teacher moves such as questioning and explaining. The second stage of this research comprised of a focus group populated by the four observed teachers and the SET teachers who supported their rooms. It was found that teachers are supported by their knowledge of subject and their students. When resources are plentiful and time is abundant, they perceived Maths Talk lessons to be a positive experience. They were bolstered by positive mindsets that were evident in their students. On the other hand, teachers identified numerous factors that they needed support with. Dealing with frustrated students with emerging language trying to communicate, and running out of time to hear all children's contributions were but two of these factors. The findings of this study have many implications for policy makers both at national and school level. Teacher's perceptions were, when it comes to implementing Maths Talk in their classrooms, they need a lot of support.

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List of Abbreviations

CPD Continuous Professional Development

EAL English as an Additional Language

ENL Empty Number Line

INTO Irish National Teacher's Association

NEPS National Educational Psychology Service

PD Professional Development

SET Special Education Teacher

Chapter 1 Introduction

In Ireland, the recently published *Literacy, Numeracy and Digital Strategy 2024-2033* (Government of Ireland, 2024) has been created to support the growth of fundamental skills for the modern evolving world. This document includes a focus on such competencies in literacy, numeracy and digital literacy and the fostering of a positive disposition towards these. Underpinning principles include programmes designed to help acquire the aforementioned competencies with a focus on professional learning experiences, the importance of early intervention, the benefits of welcoming, inclusive learning environments (embracing multiple languages) and the creation of communities of practice with a focus on developing pedagogical approaches.

This strategy was born out of a review of the *Literacy and Numeracy for Learning and Life 2011-2020 National Strategy*, which found a need for an increased focus on Numeracy and provision for learners who are more able, amongst other targets. Within the Numeracy context, this 2024 strategy in particular encourages children to "communicate, clarify and justify decisions using appropriate mathematical language…" (p. 31).

Maths Talk is the systematic use of inquiring, explaining, listening, and using various forms of communication in the classroom to help all students gain a conceptual knowledge of maths (Sztain, Heck and Malzahn, 2020). It aims to help children with "important mathematical ideas" (Kazemi and Hintz, 2014, p.14). The promotion of Maths Talk is one of the five "key pedagogical practices for the classroom" identified in the new Primary Mathematics Curriculum (DE, 2023, p.26) due to be operational in Irish classrooms in September 2024. The importance of incorporating rich mathematical discourse has been widely documented both in Ireland, and

internationally (Dooley, Dunphy and Shiel, 2014; Sfard, 2012, 2017). It has been noted anecdotally to already take place in many classrooms in Ireland, but to date there has been no formal study into its implementation in primary classrooms here.

My personal motivation for this study arrived from a life-long love of reading and problem solving. I have always known that talking about maths is important, however the term Maths Talk first came to my attention following a Number Talks webinar. I was immediately invested in trying out this new approach with my class and it has become synonymous with my maths lessons since. As a teacher and mathematics subject leader, I am interested in finding out how teachers can be supported to implement Maths Talk using the new Primary Mathematics Curriculum for Primary and Special Schools (DE, 2023) in their classes. This applies directly to my practice as it will be included in my brief to design CPD for the teachers in my school. Therefore, the aim of this research is to explore what supports teachers in 1st and 2nd class perceive they need to facilitate Maths Talk in their classrooms and how they would like to access these supports.

This research adopts a small-scale qualitative case study design. It focuses on investigating teachers' perceptions of Maths Talk and the supports which teachers perceived they possessed or needed, to help them implement Maths Talk in their classrooms. Case Study is the methodology of choice for this research as it allows the researcher to investigate teachers' experiences and views about Maths Talk in the middle classes in a contextualised manner. Chapter 2 situates Maths Talk in the context of relevant literature and emerging themes. Chapter 3 provides a detailed rationale of methods chosen, including a two-phase data collection process and ethical considerations. Findings including the need for increased time and resources, improved content knowledge and a greater sense of agency are then presented in Chapter 4 and discussed through

the interpretive lens of literature in Chapter 5. The dissertation culminates with conclusions, limitations, and recommendations for further study at the end of Chapter 5.

Chapter 2 Literature Review

This study aims to investigate teacher perspectives on Maths Talk and its implementation in Irish classrooms as a key pedagogy of the New Primary mathematics Curriculum. In particular, this research aims to discover how teachers feel they are, or could be supported to implement Maths Talk in their classrooms. This chapter presents a review of existing literature as it pertains to resources, English as an Additional Language (EAL) learners, teacher's knowledge and time as a constraint in implementing Maths Talk. Lastly, mindset and anxiety and professional development will be reviewed.

1. Resources to facilitate discovery learning and consolidate ideas

Constructivist theorists such as Bruner (1966) suggested that children learn by doing. When planning for effective mathematical discourse NEPS (2020) advocate the creation of multi-sensory experiences as well as making use supports such as multiplication squares, number-lines or calculators.

Previous studies have reported that providing concrete materials to children can help them explain their thinking. A 2010 report from the Department of the Inspectorate in Ireland recommended that children should have all of the concrete materials and resources that they need from the discovery part of their learning all the way to consolidation of learning at the end of a topic.

In order for children to use concrete materials such as the multi-sensory tools recommended by the Inspectorate above, schools must have access to funds to buy a wide and varied supply of resources.

However, anecdotal evidence of teachers surveyed suggests that a wide variety of mathematics learning resources are not always readily available in Irish classrooms (INTO, 2017). One possible reason for this may be due to funding constraints as experienced by mathematics leaders in an Australian context (Driscoll, 2017).

Concrete materials and other resources such as visual aids and digital resources have been found to help children who speak English as an Additional Language in particular (NEPS , 2020). An absence of these resources can have a considerable impact on children who are EAL learners. This will be documented in the next section.

2. EAL learners

International studies point to high proportions of EAL learners in many schools, for example in the United States of America, Araujo, Roberts, Willey and Zahner (2018) reported that this number is estimated to be around 21%. Similarly in Ireland, 23% of the population spoke a language other than English or Irish at home (CSO, 2023). In 2020, NEPS published a document to aid teachers in Irish classrooms support their students with Mathematics. In this document, they detailed how students who speak English as an Additional Language face a significant disadvantage in the Irish primary mathematics classroom, as comprehension of concepts necessitates prior understanding of the language used.

The following section documents the need for specific mathematics language, the frustration of EAL learners in attempting to be included in Maths Talk, and how teachers can utilise supports such visual aids, word banks and bilingual resources to support them in their teaching of these pupils.

Students need maths language to engage in Maths Talk

Research on word problems in mathematics highlights challenges for children who are EAL learners and who have limited vocabulary due to the need for both alphabetic literacy and competence in mathematical discourse (Moschkovich, 2015). This study also found that for a child to engage fully in Maths Talk, they must have the language to do so. The pedagogy of scaffolding was also examined through a socio-cultural lens in Moschkovich's study. In her paper, she discussed how children needed to be literate in terms of alphabetic literacy but also competent in the language of mathematics. She detailed that to attend to word problems for example, a specific type of instruction in mathematical discourse was required. Unlike texts in other subject areas, the goal and organisation of this specific maths literacy are distinct and have different requirements for EAL learners than for children who speak the language of instruction as their first language. Additionally, Moschkovich (2015) stated that significant skill is involved in order to differentiate between what is important mathematical content in a sentence, and what is irrelevant. She said students need to "focus only on the mathematically relevant information, make sense of each quantity, how quantities are related, and model the situation mathematically" (p. 1076). This is difficult for EAL learners.

Specific mathematical vocabulary is necessary for the complete understanding and demonstration of conceptual knowledge. Bruun, Diaz and Dykes (2015) found that while students may excel in computational skills, their ability to effectively apply and demonstrate these skills will be significantly hindered if they lack understanding of the mathematical vocabulary used in instructions, story problems, and other tasks involving mathematical terminology. Without a solid grasp of this specific vocabulary, students struggle to interpret and solve problems, ultimately impacting their overall performance and proficiency in mathematics and mathematical discourse.

Both Moschkovich (2015) and Bruun et al (2015) detailed the difficulties that children who are EAL learners can face in the mathematical discourse classroom. It can be concluded therefore, due to their findings and those of the NEPS (2020) document, that for a large proportion of the children in Irish classrooms who speak English as an additional language, there lies a significant disadvantage relating to mathematical discourse. Facing challenges such as these can lead to feelings of frustration for both students and their teachers. This will be detailed next.

Frustration

Lacking proficiency in the language of instruction can lead to children experiencing negative emotions such as a feeling of frustration. Among children who had arrived in Ireland as refugees, levels of frustration were reported when they attempted to participate in whole class discussions (Ní Raghallaigh, Smith & Scholtz, 2019). This report also indicated that people have had preconceived ideas about children who have arrived in Ireland as refugees, such as an ability to structure their work and reproduce material for themselves. When pupils are not able to do this, further frustration may present itself for teachers, pupils, or both.

Frustration due to not speaking English can lead to children being unable to engage in Maths Talk because it impedes their ability to understand and articulate mathematical concepts, thereby limiting their participation in discussions. The literature has shown that feelings of frustration due to an inadequate language impacting ability to join in with discussion may be something that teachers need support with.

Visual aids to support Talk Moves and participation in Maths Talk

One support that teachers can use to support EAL learners with new vocabulary is the provision of visual aids (NEPS, 2020). Bruun et al. (2015) completed an action research project

involving the explicit teaching of math vocabulary. Children involved in their research compiled information visually on a graphic organiser including drawing pictures of what they understood specific mathematical words to mean. One significant finding of their research was that visual strategies, including the use of diagrams, illustrations, and other visual aids, helped ELL students to better understand and retain information by providing clear, visual context to accompany verbal explanations.

This approach not only supported their comprehension of complex concepts but also facilitated more effective learning compared to traditional methods relying solely on verbal instruction. As a result of their research, Bruun et al. (2015) advocated that visual aids should be provided to support children (including but not limited to English Language Learners) develop their maths specific vocabulary, thereby enabling them to participate in Maths Talk more confidently and effectively.

Visual cues could prompt what Chapin, O'Connor and Anderson (2009) called *talk moves*. They gave the example of *adding on* and indicated its purpose was to create a more profound understanding of a concept by engaging a greater number of voices to discussions of that concept.

The link between visual aids and talk moves lies in their complementary roles in enhancing understanding and communication in the classroom. According to Bruun et al (2015), visual aids provide concrete representations of concepts, helping students to better grasp and remember information, while talk moves, on the other hand, are strategies used by teachers to promote student discussion and deeper thinking (Bruun et al., 2015, Chapin et al., 2009). When used together, visual aids can serve as focal points for discussion, enabling students to articulate their understanding more clearly and engage more effectively in mathematical discourse. This has multiple benefits for EAL learners as has been shown.

Visual aids have been shown to increase the specific mathematics vocabulary of EAL learners. August et al. (2023) examined the effectiveness of visual aids during an intervention for sixth-grade Spanish-speaking English as Additional Language (EAL) learners. They found that EAL learners and their peers performed better in math and academic vocabulary tests following an intervention which included visual supports being provided to explicitly teach necessary vocabulary. It can be concluded, therefore, that increasing the specific maths vocabulary of EAL learners would have a positive effect on their participation in Maths Talk.

Considering the work of both Bruun et al. (2015) and August et al. (2023), it is clear that visual aids have been found to have been a support to educators who taught EAL learners in Maths Talk classrooms. These visual aids can be complemented by talk moves (Chapin et al., 2009). August and her colleagues (2023) also utilised bilingual resources. This will be documented next.

Bilingual Resources and language of instruction

Studies have shown that when EAL students experience maths instruction in both the language of instruction and their mother tongue, their outcomes in mathematics are better (Hufferd-Ackles et al., 2004, Norén, 2008, Trawick-Smith, DeLapp, Bourdon, Flanagan and Godina, 2022). Both Trawick-Smith et al. (2022) and Lake and Beisley (2019) found that when teachers communicated with children using even a little of their home language, children interacted more with their peers and participation in play was improved.

Access to appropriate resources is vital, as has been shown in the August et al. (2023) study. In their study, appropriate bilingual resources positively impacted outcomes for students who had a first language different to the language of instruction in their classrooms. Teachers involved in August's study used Spanish and English resources to utilise the students' home languages as much

as possible. The also provided “bilingual glossaries; and opportunities for students to engage in partner talk in their home language” (p. 138). As a result of the use of bilingual resources, mathematics results improved. This finding has an impact on EAL learners who are participating in whole-class discussions.

It can be concluded therefore, that the child’s own language is an important tool for learning which can be used in the Maths Talk classroom by the use of bilingual resources. One such resource is a Translate App, the use of which will be elaborated upon in the subsequent section.

Translate Apps

Lake and Beisly (2019) recognised the number of EAL learners worldwide and advocated for the use of Translate Apps to aid communication in the classroom. The benefits of using Translate Apps, they said, were numerous. These included improved communication between teachers and students and between students. Barriers can be removed and relationships improved, Lake And Beisly (2019) suggested, but there are some prohibitive factors, including cost, to be taken into account. They examined three apps in their article: *Speak and Translate, Microsoft Translator, and Google Translate* and concluded that teachers with English Language Learners (ELLs) in their classes should broaden their strategies to incorporate the use of translation applications. This is essential in recognising the child’s right to feel valued, respected, and to express their knowledge in their native language. Mobile learning devices facilitate this process by enabling them to communicate effectively in their home language. Translate Apps may benefit overall communication within the classroom for EAL learners, and may improve relationships between teacher, students and their peers. Limited literature is available however, detailing the effectiveness of these translation applications in teaching EAL students mathematics. More research is needed to evaluate the effectiveness of Translate Apps for the purposes of

implementing mathematical discourse in the primary classroom. It is unclear, therefore, about how useful they would be given the limited data in Translate Apps.

Some research has been done into the effectiveness of using ICT for the purposes of teaching English to students (Thamarana, 2016). Following their research, Araujo et al. (2018) concluded that further research is necessitated around "asset based discourses and practices to support EL's in mathematics" (Araujo, 2018, p. 911).

Summary

Previous studies have reported that Maths Talk can be difficult , and lead to frustration, for children who experience language difficulties, including children who speak English as an additional language. Resources such as concrete materials, visual aids and Translate Apps can be effective in supporting these children to participate in mathematical discourse and Maths Talk. However, access to relevant materials is limited in Irish classrooms. Studies of Maths Talk among EAL learners report specific implications for Professional Development needed by their teachers and these will be outlined in the relevant section below.

2. Teacher Knowledge

Building on the findings of Shulman (1986) and Ball (2005), Ball, Thames and Phelps (2008) found that in order for teachers to teach effectively in their classrooms, they need knowledge of both subject matter and pedagogy. This can be applied to mathematics lessons as found by Delaney (2005) and therefore further applied to Maths Talk. There is a sizable body of research on the types of knowledge needed for implementing mathematical discourse including that of Gaffney and Faragher (2010). Sfard and Avigail (2007) for example, reviewed literature about Mathematical Discourse and concluded that "school learning requires an active lead of an experienced interlocutor" (p.1).

Additionally, Hundeland, Carlsen and Erfjord (2020) reiterated the importance of teacher competency in creating opportunities for children to participate in mathematical discourse. They conducted a study, detailing the study of four kindergarten classes, two of which were taught by teachers who had undergone specific professional development in mathematics education and two control classes taught by teachers who hadn't. They found that the knowledge of (kindergarten) teachers is essential for students to understand and apply mathematical ideas and concepts, because these educators must be capable of providing pupils with opportunities to engage in mathematical debates.

Ball, Thames and Phelps (2008) separated the type of knowledge needed for teaching into two categories: Subject Matter Knowledge and Pedagogical Content Knowledge. Although Ball et al.'s work (2008) included a total of six categories of teacher knowledge under these two overarching themes, three of the most relevant to this study will be described next under the headings of Specialised Content Knowledge, Knowledge of Content and Students and Knowledge of Content and Teaching.

Specialised Content Knowledge (SSK)

Ball et al. (2008) called SSK the "mathematical knowledge and skill unique to teaching" (p. 400). By teaching more than ten subjects each week teachers in Ireland are "generalist teachers" and this makes it virtually impossible to have expert knowledge in every subject area they teach. (Hourigan, 2010, p. 1). Teachers must have a thorough understanding of mathematics in order to incorporate important meta-practices in pedagogy, such as math talk, productive disposition, modelling, cognitively demanding assignments, and evaluation (Dooley et al, 2014).

Evidence from both Hourigan (2010) and Dooley et al. (2014) shows a requirement for teachers in Ireland to have a deep understanding of mathematics in order to successfully

implement Maths Talk in their classrooms but difficulties such as the numerous other subjects on their timetable are recognised as a constraint as found by Hourigan (2010).

Knowledge of Content and Students (KCS)

Teachers need to have an extensive knowledge of both the content that they are teaching, and the students that are in their class (Ball, 2005 and Delaney et al., 2008) Knowing why a student may arrive at a wrong answer is important (Delaney et al., 2008) because teachers are essentially placed 'on the spot' during lessons.(Hourigan 2010, p.1) Although previous studies of KCS did not report on the use of Maths Talk, it is possible that the same types of knowledge would be needed in Maths Talk lessons.

In an article which investigated how much Mathematics subject matter knowledge (MSK) was needed to teach at primary level, Hourigan (2010) reaffirmed the importance of mathematics subject matter knowledge is as "central to effective teaching" and also that it "influences a teacher's ability to 'think on one's feet' when responding appropriately to children's questions, unexpected answers and misconceptions" (p. 1).

It is vital that a teacher implementing Maths Talk in their classroom has knowledge of both content and students as Maths Talk lessons require teachers to be able to recognise and interpret the strategies of their students immediately.

Knowledge of Content and Teaching (KCT)

The new Primary Curriculum Framework for Schools and Special Schools (DE, 2022, p.23) suggests that knowledge of pedagogy begins with initial teacher education and evolves and deepens through reflection on practice, conversations with colleagues, and continuing professional development. Ball et al. (2008) called Knowledge of Content and Teaching "knowing

about teaching and knowing about mathematics" (p. 401). Delaney et al., (2008) agreed with the Ball et al. (2008) definition of KCT and gave an example "knowing instructional advantages of different representations of 75-18" (p.8). As already mentioned, teachers need to make quick assessments of their students' strategies and misconceptions in order to lead a Maths Talk (Hourigan, 2010). They also need to know how to simplify and break down difficult mathematical concepts with methods such a mathematical modelling (DE, 2023). It is in these situations that their knowledge of pedagogy, in particular, content and teaching is a support to them.

To summarise, it has been shown that teacher knowledge of both content and pedagogy are essential for the successful implementation of Maths Talk in their classrooms, and that this knowledge serves as a support to teachers. Like the findings of Hundeland et al., (2020), continuous professional development (CPD) and training are instrumental in teacher knowledge. This can be applied to the knowledge needed to implement Maths Talk in the classroom. CPD will be documented in a subsequent section of this literature review.

3. Supports needed arising from time constraints

Time is a well-documented issue for all teachers. Smith, Bill and Sherin (2020) recognised the issue of time when planning for a successful discussion to take place and how the discourse can be impacted due to limited time.

As the body of research on this topic is relatively limited relating specifically to the implementation of Maths Talk, initially literature was sought in the more general sense, that is, how time issues can be mitigated in the Maths Talk classroom. The following is a review of literature surrounding this theme, beginning with the aims of a successful mathematical discussion, followed by some approaches on how this can be achieved, where time is a considerable factor. Next, supports needed arising out of time constraints are identified.

Time for productive mathematical discussions

One aim of any productive mathematical discussion is to get the students to a stage where they are connecting their ideas with those of others (Hufferd Ackles et al., 2004, Smith, Bill and Sherin, 2020,). Smith and Stein (2018) posited that to foster effective mathematical discussions, teachers should first define a clear and specific learning objective then choose an appropriate task. Hufferd-Ackles, Fuson and Sherin (2004) completed an intensive case study over one year, using a framework that they developed called *Math-Talk Learning Community* which included the development of a rubric across four levels (0-3), culminating in Level Three which where students actively observed each another's thoughts Hufferd-Ackles et al. (2004) suggested that students who are not presenting to the class need help to actively listen and prepare to ask questions, in order for a successful Mathematics Discourse community to prosper.

Smith et al. (2020) supported this work by stating that minimizing passive listening is crucial to facilitating productive class discussions. In their work encompassing five practices for orchestration of productive maths discussions, they acknowledged that time is a prohibitive factor in both keeping the whole class engaged in Maths Talk and that time can run out easily in a maths lesson. They proffered some suggestions on how to mitigate this factor such as spreading lessons over two days and engaging the use of timers. They reinforced that the goal of a successful maths lesson is not that all students ultimately all reach the correct answer simultaneously, but to have all students progress. They said that students should be positioned so that they can make sense of the discussion, shifting the focus from an answer-driven environment.

The research of Smith et al. (2020) echoes the work of Chapin et al.'s (2009) *Talk Moves*, where they suggest that moves such as *adding on* and *revoicing* can deepen engagement, understanding and can be utilised for clarification seeking purposes.

Smith and her colleagues (2020) proposed that to use moves like these, was to keep the entire class accountable, therefore making best use of their time together. Where time is an issue, Smith's pedagogies can support the teacher in engaging all students and optimizing their collective time during whole class mathematics discussions. More supports to mitigate time constraints will be presented next.

Supports needed arising from time constraints

In an Australian context, Driscoll (2017) reported that professional learning for graduate teachers can include an hour per term with a mathematics lead teacher to review, establish goals, clarify ideas. In Ireland, the Droichead (Teaching Council, 2017) process enables a newly qualified teacher to have professional conversations with a mentor teacher who is generally also a colleague, but these meetings are only formally scheduled to take place twice in an academic year (Teaching Council, 2017), although informal meetings may occur. Despite the presence of this opportunity for newly qualified teachers, there is currently no formal mechanism to create time for professional discussion outside the Droichead process. This is highlighted by Delaney (2005), where a participant in his study (although they were an experienced educator) commented on the inability to find time for such discourse while the researcher concluded that both "time and determination" (p.247) are key factors in effective professional development.

In summary, the above literature has shown that time can be a prohibitive factor in the successful implementation of a whole-class mathematical talk. Time is an issue because of the time it takes to hear the whole class speak while keeping the rest of the children engaged as well as time to plan and reflect through means such as professional conversations.

4. Growth Mindset and Maths Anxiety

A supportive classroom environment which promotes the implementation of Maths Talk is one that values a Growth Mindset (Boaler 2022, Dweck, 2019). Boaler (2022) described the brain as constantly growing and developing, and talked about brain connections forming when conversations took place. Similarly, Dweck (2019) considered the concept of a growth mindset as one which facilitates the development of intelligence through hard work, "good strategies and input and mentoring from others" (p. 21)

A growth mindset can motivate students to undertake additional challenges and demonstrate greater persistence in the face of setbacks, potentially enhancing their level of achievement (Dweck 2019, Boaler, 2022). The growth mindset theory can be effectively applied to facilitate the implementation of Maths Talk by emphasising the importance of learning from others and fostering brain development through engaging and substantive rich mathematical discussions. However, if children are anxious about Mathematics, they may have a fixed mindset and perceive their maths ability as something that is fixed and cannot be changed (Boaler, 2022).

Maths Anxiety (MA) may be described as, "an international dilemma" (Chinn, 2020 p.61), "a person's negative affective reaction to situations involving numbers, math and mathematics calculation (Ashcroft and Moore, 2009, p.197) or relating "inversely to positive attitudes toward mathematics" (Hembree 1990, p.33). Maloney, Schaeffer and Beilock (2013) provided some strategies to alleviate MA, included with these was to increase numerical processing skills. They

also suggested “recontextualising the situation” (p.123). Klee et al. (2022) agreed that contextualisation was important and they provided some concrete preventative strategies for maths anxiety in the classroom, some of which will be detailed next.

Klee et al. (2022) examined MA through the theoretical lens of control value theory. Although the focus of their study involved high school students, their findings have implications for all maths learners. Klee and her colleagues found that in order to alleviate MA there should be an emphasis placed on understanding instead of operation in order to enhance students self-confidence and can achieve mastery. They also suggested that new language and vocabulary are dissected with the whole class. Finally, Klee et al. (2022) claim that students should always be reminded that “getting the right answer is not the only goal of learning” (p. 54). These findings corroborate the work of Boaler (2016), where she said that strong mathematics students develop conceptual knowledge. Boaler said they do this by engaging in risk-taking and persevering through productive struggles with unfamiliar concepts.

Overall, studies have shown that when students have a growth mindset, measures such as specific instruction in language and a focus on conceptual understanding are taken to reduce Maths Anxiety in the classroom, the environment is more conducive to successful mathematical discourse taking place. Some positive results have come from using Maths Talk in particular to combat Maths Anxiety (Peterman and Ewing, 2019) but there is need for further research in this area.

5. Professional Development

This study aims to understand how teachers feel they could be supported to implement Maths Talk, as one of the five key pedagogical practices of the new Primary Mathematics Curriculum (DE, 2023). Professional development for teachers is frequently associated with

education reform (Sykes, 1996) and can have a positive impact on the Math Talk classroom (Hundeland et al, 2020). Previous work in the literature indicates that one barrier to the successful implementation of any new curriculum could be the reluctance of experienced teachers to embrace change (Prendergast et al, 2018, Handal and Herrington, 2003). These findings echo the work of Lortie (1975) who suggested that teachers adopt a conservative approach because they are anxious about "trying the unfamiliar" (p. 234). Handal and Herrington (2003) call curriculum change a "complex process" (p.60) and mention that teachers' belief systems are a major factor in the success of any new curriculum. It is imperative, therefore, that any Professional Development (PD) undertaken at this time take into account *what* teachers feel they need support with, and *how* teachers want to receive the new Primary Mathematics Curriculum.

Kennedy (2016) conducted a review of the effectiveness of twenty-eight professional development (PD) programs in the United States. Her study included articles from the year 1975 until 2013. Although Kennedy's review is a large-scale paper with many findings, the relevant findings will be addressed in the following sections.

Knowledge needed by those delivering Professional Development

Kennedy (2016) found that content knowledge was the most widely-referenced requirement for professional development in the literature that she examined. However, she revealed that when content knowledge was the exclusive focus of the PD, there was less of an effect on student learning. Among her recommendations and implications for future research, Kennedy suggested more attention be paid to *who* is delivering Professional Development. She referenced Shulman (1987) and Hill, Rowan and Ball (2005) with regards to content and pedagogical knowledge for teaching mathematics but postulated that little research has been done into the types of knowledge needed by those *delivering* Professional Development. Kennedy

found that many of the most effective PD programs that she examined were run by professionals who were, or had been, teachers themselves and could base their programs "on their own personal experience or expertise" (Kennedy, 2016, p. 973). The nature of professional development expertise, the process of choosing professional development providers, the training provided to them for their jobs, and the methods used to evaluate their effectiveness are not extensively covered in the literature, according to Kennedy, and there is a need for further research in this area.

Another key finding which arose from this body of research concerns teacher motivations to undertake PD, whether they were voluntary or mandatory. Kennedy found that when teachers voluntarily undertook PD, the results of the program were more positive. She acknowledged however, the potential of any PD study cannot be measured where the participants are mandated to attend.

Professional learning communities

Kennedy (2016) also examined the role of communities of practice which she called "professional learning communities" (p. 972) and found a variance in their effectiveness, including one which had a negative effect on the learning of the students involved. Dalby and Noyes (2022) contradict these findings and instead advocate that a community of practice strategy for Mathematics teachers in a Further Education context could improve the professional learning of the workforce and therefore the learning of the students. They indicate however, that for these positive outcomes to come to fruition, there must be "strategic direction and leadership support" (p. 431) and above all, a common understanding of best practice is necessary.

In an Irish context, Dooley et al. (2014) advocated for teachers to work together in order to implement change, building relationships and structures that support the work of their

colleagues. They also said that teacher agency is key. Teachers need to become active participants in their individual professional development by reflecting on their interactions with both programmes of professional development and their own teaching. (Dooley et al., 2014, p.123). NEPS (2020) supported these findings and said “Professional development and peer support can improve teacher skills and confidence, leading to more classroom enthusiasm and increased positivity” (p. 14).

Lappan (1997) found that having an experienced colleague to discuss and dissect a lesson with in great detail was a support in creating a discourse community in her classroom. Gibson and Brooks (2012) expanded on this and said that successful curriculum implementation was found to depend on a number of factors including having other teachers in the same class level to collaborate with, but also having enough resources at the school, having funding available for ongoing professional development, and having a "go-to person" to ask questions of” (p.18). Gibson and Brooks (2012) lend further weight to the work of Dalby and Noyes (2022) and the aforementioned piece about adequate resources in relation to EAL learners.

In summary, CPD for teachers should be based around content knowledge and/or pedagogical knowledge, and can exist in a community of practice approach where there is clear leadership and a shared vision. The findings of Kennedy (2016) are in contrast with those of Dalby and Noyes (2022), Dooley et al. (2014), NEPS (2020), Lappan (1997) and Gibson and Brooks (2012) who advocated that teachers can benefit from peer learning opportunities.

Conclusion

In summary, this literature review has outlined the context for exploring Maths Talk as it pertains to teacher supports. It has examined themes that have emerged in relation to resources that may support teachers with particular reference to EAL learners. The research points to visual aids and Translate Apps being of benefit to teachers and students. The literature around teacher knowledge pointed to a requirement of a deep knowledge of both content and pedagogy in the maths classroom. Although it appears that time may be an issue for teachers when it comes to professional conversations and having sufficient time to engage in mathematical discourse with students, it appears that there may be strategies available to teachers to mitigate these factors. Research revealed how growth mindset may support teachers and students, but that maths anxiety could impact on the Maths Talk classroom. Finally, professional development was examined under the guise of professional learning communities which have been overwhelming shown to promote effective teacher training. These emerging themes have formed the basis of an observation tool (see Appendix E) together with which they formed the structure of a focus group (for questions see Appendix F). These methodologies are outlined in Chapter 3.

Chapter 3 Methodology

The purpose of this chapter is to introduce the research methodology for a qualitative case study regarding to explore how teachers perceive they are supported or can be supported in implementing Maths Talk in 1st and 2nd class. A mixed methods case study was conducted with of first- and second-class teachers, and SET teachers that work with these classes, in a primary school in a large urban vertical coeducational school in the Republic of Ireland. The aim was to explore Maths Talk in the context of new Primary Mathematics Curriculum (DE, 2023) and how these teachers perceive they are or could be supported in its implementation. The applicability of a qualitative interpretivist approach to this study is discussed in depth in this chapter. The research design including the methodology, sampling procedures, data collection instruments, analytical approach and ethical considerations are primary components of this chapter.

Research Question

This study sought to answer the following research question: How do first- and second-class teachers believe they are supported or can be supported to implement Maths Talk, in their classrooms?

Methodology Selected

A qualitative study was judged to be an appropriate design for this research. While quantitative approaches were also considered, a qualitative approach was ultimately chosen because of multiple methods of data collection incorporating a case study, where enquiry is a prominent feature (Cohen, Manion and Morrison, 2017). The primary purpose of case study research is to undertake a detailed analysis of an issue, within its setting, to comprehend the issue from the participants' perspective (Harrison, Birks, Franklin and Mills, 2017) which appealed to

this researcher because of their interest in developing teacher Professional Development (PD) given their three-fold positionality in this study.

Research Paradigm

A paradigm can be defined as “a set of basic beliefs” (Guba and Lincoln, 1994, p.107). The paradigm functions as a conceptual framework that directs the researcher's behaviour because it is in line with the researcher's core assumptions and ideas about how the world is perceived (Wahyuni, 2012). The paradigm chosen by the researcher guides the nature of the study from the design to the analysis (Cohen et al., 2017). Interpretivists believe that social context and individuals' perspectives shape reality. They understand that via social contact, people with different backgrounds, preconceptions, and experiences all contribute to the ongoing fabrication of reality that exists in their larger social environment (Wahyuni, 2012). It is for that reason that this study adopts an interpretivist paradigm. This paradigm suited the design of the research because the research sought to understand teachers’ beliefs and was situated in a school, and therefore social, setting.

Positionality

Positionality is significant because it calls for the researcher to identify and admit their opinions, values, and beliefs in connection to the investigation process (Manohar, Liamputtong, Bhole and Arora, 2017). The researcher’s positionality in this case study was three-fold, as a teacher, a researcher and as a maths leader/middle manager in a primary school.

Research Sample

Convenience sampling was chosen for this research due to the scale of the study and the time-frame applicable. Teachers in this case study were also recruited because of the class levels (first and second class) they were teaching or supporting. These year groups were chosen because of the researcher's experience in teaching the classes, and subsequent knowledge of the maths curricula for first and second class, which yielded good opportunity for rich Maths Talk. Teachers ranged from newly qualified to very experienced and their initial teacher education encompassed three curricula in Ireland. The had varying levels of experience in first and second classes and some had experienced teaching abroad in England and Abu Dhabi.

The support of the principal and Board of Management of the participating school was gained through a formal letter (see Appendix A) and consent sheet (Appendix B). After the consent of the BOM was granted, teachers were invited to take part in the research by email, the contents of which included an information sheet (see Appendix C). Following informed consent, the parents of the participating classes were furnished with an information sheet (see Appendix D), which reassured them that children were not the primary focus of this study and that no information would be gathered regarding their children. It was made clear at all stages of the recruitment phase, prior to the observation and at the beginning of the focus group, that participants were free to opt out at any stage (BERA, 2018, p.9). The researcher and supervisor's email addresses were provided should participants have required further information. All teachers signed consent forms indicating that they understood what the study involved and that they wished to participate.

Data Collection

While other, more quantitative methods of data collection were considered, they didn't contribute the rich, descriptive data that case observation and focus groups do (Harrison, Birks, Franklin and Mills, 2017). These methods were also used as the data collection instruments because of their applicability to qualitative studies (Cohen, Manion and Morrison, 2017). Data collection took place in two stages with the findings from the analysis of the observational data informing the focus group.

Observations, and in particular structured observations, involve looking at and noting in a deliberate manner (Rooney and Boud, 2019). Observation in educational research has many benefits, including (but not limited to) the ability to watch events in real time, as they happen (Cohen et al., 2017). It is for this reason that observation was chosen as an appropriate method of data collection for this case study. The tool was adapted to create a focus on the work and talk of the teacher (and not including the pupils), for ethical reasons (see Appendix E). One mathematics lesson taught by each of four class teachers was observed in January 2024. Each lesson was of 30-40 minutes duration approximately. Data was collected in each lesson using a printed adapted version of the Huffered-Ackles (2004) rubric. This was done in an attempt to maintain objectivity. The observations and the data were analysed thematically using a framework developed by Braun and Clarke (2006). A deductive approach was then taken from the themes which emerged, together with themes which came from the literature review, and questions were formulated to structure the focus group (see appendix F). These questions were designed to be open ended as per Cohen et al. (2017) guidelines and the focus group was planned for a mutually suitable day and time.

According to Cohen et al. (2017) the benefits of focus groups are numerous. They yield a view of the collective, rather than the individual. They are time efficient and are a useful tool for collection of mindsets and tenets while also lending themselves to being used well in conjunction with observations (Cohen et al., 2017). Although they involve a small number of participants, they provide rich, qualitative data. The focus group took place in February 2024. It took one hour. Four classroom teachers and two SET (Special Education Teachers) who all worked with first and second class took part. It was recorded using an audio recorder. All efforts were taken to ask non-judgemental, open questions of the participants in this study. It was recognised that Maths Talk has just been formally introduced to teachers in Ireland as a key pedagogical practice of the new Primary Mathematics Curriculum (DE, 2023). It was therefore possible that some teachers were not explicitly using it in their classrooms. Teachers were reminded that the new curriculum is at its infancy stage and that they were not yet expected to have implemented Maths Talk in their classrooms in order to alleviate embarrassment or insecurity. Following the focus group, and as per the last question (a list of which can be found in Appendix F) teachers worked together to complete a mind-map (see Appendix G) based around the supports they feel the need to implement Maths Talk in their classrooms, and how they would like to receive these supports.

Ordering statements in order of preference (Q-sorting as in Rost, 2020) was considered but ultimately Mind-Map was chosen because of its “pleasing graphical format for representing key themes raised during (the) focus groups” (Burgess-Allen and Owen-Smith, 2009, p. 406). Fearnley (2022) advocated for the use of mind-maps in the thematic analysis of qualitative research because of their time-effectiveness and their ability to help the researchers interpret the themes that emerge. It was hoped that the mind-map would be a pleasant and informal end to the focus group that would also yield rich data.

Ethical Considerations

There were several ethical principles considered in the design of this study which guided how the research was conducted. Ethical approval (Appendix I) was granted for this study by Marino Ethics in Research Committee.

Consent and Autonomy (BERA, 2018, p.9)

Informed consent of participants is an important ethical consideration when undertaking to use observation (p.471) and focus groups (p.442) as a research methodology (Cohen et al., 2017) Consent forms (Appendix C) were distributed to the participants accompanied by an information sheet. Although children were not be observed, information sheets were sent to the parents of the children in the applicable classes (see appendix D). All forms provided contact details of the researcher and supervisor and communicated the right to withdraw consent at any time.

Confidentiality (BERA, 2018, p.18)

To protect the "participant's right to privacy" (Cohen et al., 2017, p.92), and the anonymity of the children in the classes involved, it was decided that classroom observations would be recorded by a written observation tool only. The focus group was audio recorded and stored on a password protected device. The name of the participating school was not disclosed, to protect the anonymity of the participants. Observations were recorded using pseudonyms and did not contain any identifying data. The focus group took place in a quiet room where participants could not be overheard by individuals not involved in the study. At the beginning of the focus group, participants were asked to respect the confidentiality of the other participants. Participants were also asked to refrain from using names or identifying

information during the focus groups. Pseudonyms were used on transcripts. The lesson observation sheets, digital audio recorder and physical copies of documents relating to focus groups were kept in a locked cabinet. Data gathered was downloaded on to the researcher's personal laptop and stored under password protection. The key to pseudonyms was also stored in a locked filing cabinet elsewhere. Contextual information will be presented in the dissertation in a manner that protects the identity of the school and participants.

Fidelity

It was undertaken by the researcher to complete this research as a matter of responsibility to all stakeholders for giving their time and consent to partake in this study.

Incentives

No incentives were offered, however, all participants were informed of the value of their participation in contributing to a study that is timely and has not yet been researched in Ireland to date.

Data Analysis:

Thematic analysis is "the process of identifying patterns or themes within qualitative data" (Maguire and Dalahunt, 2017, p.2). Braun and Clarke (2006) presented a six stage approach to thematic analysis (p. 87) and their framework guides this stage of data analysis. Some phases presented below are two-fold as the observation data were collated and analysed thematically before questions for the focus group were generated. Where this is the case they are presented in two paragraphs with observation information preceding the focus group information. Notes were taken and codes were continuously added to and refined throughout the process as recommended by Braun and Clarke (2006).

1. Familiarizing yourself with your data

Phase one of the observation included inputting the written observations on to a table using Microsoft Word. The number of occurrences of some teacher moves were recorded and noted for inclusion in the focus group questions. Notably, where no occurrences of some moves were recorded, this was also noted.

The first phase of analysing focus group data included the transcription of the audio recording. This was done using Microsoft Word. The researcher then listened to and read the transcript numerous times to ensure they were familiar with the data and that the transcript matched the audio.

2. Generating initial codes (appendix H)

Initial codes from the observations became very clear and were recorded in a Microsoft Word document as questions that the researcher wanted to know more about. Coding in qualitative research are defined as he process of organizing and sorting qualitative data (Stuckey, 2015).

Initial codes were generated using the transcript and a two column table in Microsoft Word. Where codes began to emerge, they were recorded in the right column and corresponding quotes were copied into rows on the left. Some frequent codes emerged quickly e.g. time to listen, teacher knowledge of strategies and professional development opportunities.

3. Searching for themes

A theme denotes a certain degree of patterned response or meaning within the data set and highlights an important aspect of the data in relation to the research question (Braun and

Clarke, 2006). From the observation codes, some themes emerged and questions were formed. These questions were based on emerging themes and were formed with open, non-judgemental attitudes in mind.

By taking into account how several codes might come together to produce an encompassing subject, codes were grouped into possible themes. Focus group data themes were recorded using highlighted text in Microsoft Word.

4. Reviewing themes

Provisional themes were reviewed and refined. Data within the themes were examined for coherence and reviewed to ensure there was a clear distinction between them (Braun and Clarke, 2006). Mind-maps were used to aid this process because of their clear graphical format (Burgess-Allen and Owen-Smith, 2009). At this point the entire data set was re-read in order to establish if the themes worked, and to code any additional data that may have been disregarded or missed in the earlier stages (Braun and Clarke, 2006).

5. Defining and naming themes

When a "satisfactory thematic map" (Braun and Clarke, 2006, p. 92) was compiled, the researcher returned to the transcript of the focus group data and further defined and refined the themes. This was done in order to ensure coherence and consistency with the accompanying extracts (Braun and Clarke, 2006). As per the Braun and Clarke (2006) guidelines, careful consideration was given to telling the story of each theme as it fit into the overall story, and as they related to the research question.

6. Producing the report

The “final analysis and write-up” then took place (Braun and Clarke, 2006, p. 93). At this stage, the researcher endeavoured to include as much evidence in quoting from the data set to ensure the predominant themes which emerged were sufficiently supported by the available data and relate them to the research question.

It was found that these stages were not linear and the researcher moved forward and back within them while analysing the themes that arose.

Validity and Reliability

All efforts were made in this study to create thick descriptions in order to provide what Yin (2009, p. 122-124) called a “chain of evidence”.

Limitations

The sample size of this study is one limitation of this study because it does not lend itself to generalisability, which is a limitation commonly associated with Case Study according to Cohen et al. (2017). However, the range of experience and geographical contexts of the teachers may have mitigated some of these circumstances. Subjectivity and observer bias are also possible limitations noted by Cohen et al. (2017). However, all efforts were taken to reduce these factors through the use of a research based, adapted rubric (Hufferd-Ackles et al., 2004). It was felt that the informal atmosphere which focus group lends itself to, yielded rich, descriptive data, a benefit attributed to case study.

Summary

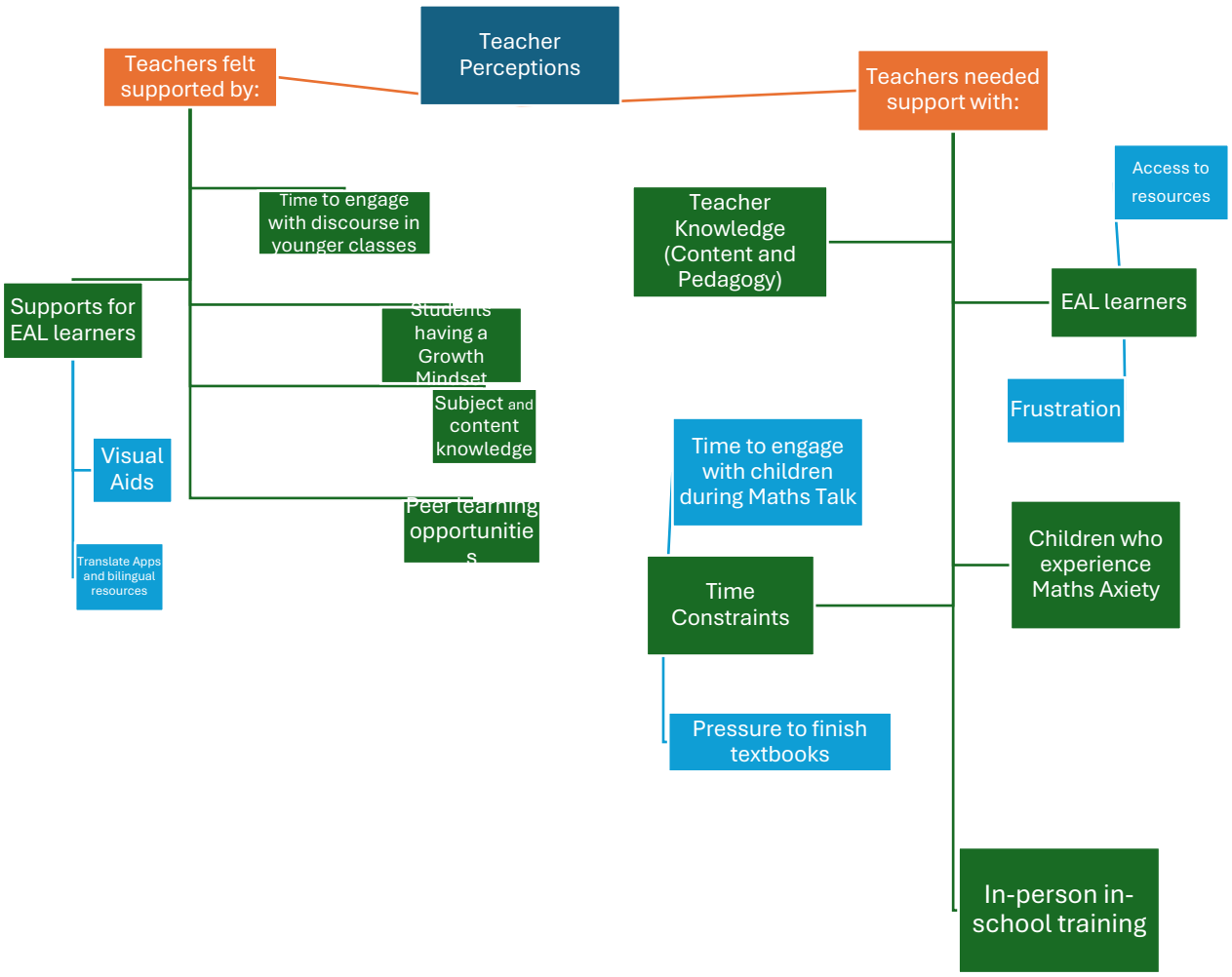
In summary, a qualitative, interpretivist approach was deemed most suitable for this case study. Data were gathered and analysed thematically, the results of which will be presented in Chapter 4.

Chapter 4 Findings

This chapter presents the findings of the analysis, giving insight into supports that teachers felt they had and supports they felt they needed, to implement Maths Talk in their classrooms. The analysis revealed six main themes: Resources, EAL learners, Teacher Knowledge, Time Constraints, Growth Mindset and Anxiety and Professional Development. Each theme is divided into supports felt and supports needed and is further subdivided into subthemes as illustrated below. This chapter provides a summary of these findings.

Figure 1

Thematic map of findings



1. EAL Learners

During the classroom observation stage of this study, it was observed that one teacher had word banks and bilingual resources available for EAL children in her class. She supported the children to engage with these resources in small groups where they were mixed with English-proficient peers. When it came to Maths Talk and whole-class discussion, the teacher provided children with these word banks to support their explanations. Mini whiteboards were available for children to show their teacher visually what they meant. The teacher encouraged the use of whiteboards to find out what the children were drawing attention to, and then supported this with word banks.

Teachers involved in this research found it difficult to provide support for children in a way which enabled them to think and communicate mathematically rather than constraining them or making assumptions about their thinking. Another challenge for them was managing disagreements which arose during Maths Talk when children had a restricted vocabulary. The following sections detail the supports those teachers felt they had, or needed, to implement Maths Talk effectively in their first- and second-class classrooms.

Supports teachers perceived they had.

Visual Aids to support Talk Moves and participation in Maths Talk

Visual aids were identified as being a support for teachers endeavouring to implement Maths Talk in their classrooms. Christine communicated that she feels more confident and supported in implementing Mathematical Discourse when she uses visual aids and posters that have suggested phrases for initiating respectful dialogue between students. During classroom observation, she was observed referring to these posters at the beginning of her lesson (a sample

of which is included below in Figure 1). She voiced “You can agree, you can disagree, or you can add something to your partner’s strategy e.g. I agree with you and I’d like to add something…”. In the focus group, when reminded of this approach, she described using these posters nearly every day. She said it helps the children in her class, in particular children for whom English is not their first language. Other teachers in the focus group agreed that this was a great support to use. “Wow, what great open statements!” Jane exclaimed, “I must try that”. Visual aids such as posters promoting Maths Talk were a support that teachers involved in this research perceived to be beneficial for them and for their students. Christine also documented using Translate Apps and bilingual word banks. These will be documented as a support in the next section.

Translate Apps and bilingual resources as a support

Translate Apps and bilingual resources supported teachers involved in this research when talking about maths with their classes.

> “Yeah, it really helps me as a starting point, and actually in the middle of a lesson sometimes not always just maths lessons either” continued Christine after speaking about resources. “I’d say I refer to them most days, if not every day. They are a great support to my lesson as I can refer back to them to help the children get started in their discussions with each other”.

Christine also added to the conversation about supports by noting the benefits of translation apps and word banks (a picture of the English version is included below in Figure 2) as language supports to EAL learners and all children in her class: “I leave them on the table for children who don’t have as much English, but really everyone benefits from them”, she said.

Visual aids/posters and word banks (bilingual or English only) are supports that these teachers agreed helped them to implement Maths Talk in their classrooms. They suggested that supports

such as these benefit all children, including children who are EAL learners. Teachers feel supported in implementing Maths Talk when they use these resources. Apart from general English language skills and language specific to mathematics, teachers perceived these resources to be relationship affirming and valuable in communicating to children who are EAL learners.

Supports teachers perceived they needed

In this group teachers found it difficult to implement Mathematical Discourse in their classrooms when children in their class did not have English as their first language. Teachers felt like they needed the support with this and the concrete materials may provide some assistance. However, in their experience, access to these resources was not always available.

Support needed with explaining and justifying in Maths Talk

Teachers reported that they needed support to help children with EAL to explain their mathematical strategies and justify their answers. Sofia observed children work out the correct answer who subsequently had difficulty explaining their strategy “They can’t articulate what they have on their whiteboard”. Similar difficulties were noted among children who had recently arrived from other countries without English, such as children from Ukraine. Teachers noted that the recently arrived children had well developed computational skills but were not able to explain their strategies nor justify their answers. While the participants explained “We found that a lot of the children that came from Ukraine had really strong maths skills” (Sofia), these children “found it very hard to explain… and were very stuck to the algorithm I guess” (Jane).

Supporting children to talk about their answers and strategies was a particular skill that teachers felt they needed support with: “You don’t want to put the words in their mouth. It’s hard to know the best thing to do there”. (Sofia) The same teacher articulated the difficulty in wanting to support children with their language, while maintaining some level of cognitive demand by not

jumping in with a strategy. She didn't want to suggest a strategy that she thought children *may* have used because it would be working under a presumption.

Accessing resources when teaching EAL learners

Although teachers felt that resources such as visual aids, word banks, Translate Apps and bilingual resources were a support to the EAL children in their classes, and they felt supported in their teaching when they had access to them, not having adequate access to these aids was something that teachers felt they needed support with. Teachers' perspectives on these resources will be detailed below.

Teachers in this group felt that tangible, concrete materials supported their teaching of EAL learners, particularly in Maths Talk. Jane made the point that for children who don't have English as their first language, Number Talks are incredibly difficult. Children have argued disrespectfully, Jane continued to say, because "what they see in their head isn't what they have the language to explain". She described a huge jump from the concrete to the abstract for children who have English as their second language and continued to say that the provision of concrete materials is very important for EAL learners to have access to. She felt strongly that these materials be available during, predominantly oral, Maths Talk lessons. These sessions are made easier with the provision of concrete materials as an aid to help children explain their thinking. Jane added however, that the availability of concrete materials to support students explaining their thinking is a challenge. Most teachers in the focus group agreed that these resources aren't readily available in Irish schools and certainly aren't commonly used by children in the senior classes. This is a challenge for teachers in implementing Mathematical Discourse in their classrooms, and is something that they felt they need support with.

> “In terms of the arguing, with the kids that are EAL learners? They need concrete materials. The number talks can be very hard for (them) because there's no visual, you have to be able to imagine it in your head.” (Jane)
>
> “It’s abstract” (Mary)
>
> “That can cause kids who aren't generally argumentative in terms of maths, to argue more for, that they’re right because what they've pictured in their head is right to them and they don't have the concrete materials in front of them to be able to manipulate it and see it the way it actually is. And we just don’t have access to all of the resources that we need in Irish classrooms, that’s the norm but it’s hard”. (Jane)

These teachers felt that lack of access to varied and appropriate concrete materials, particularly in the senior classes, was something that they need support with in implementing Mathematical Discourse in their classrooms.

Findings pertaining to frustration and managing disagreements with EAL learners

Teachers also needed support to manage disagreements in mathematics lessons which arose of misunderstandings when children with EAL did not have sufficient words to explain why they disagreed. When questioned about areas they needed support with, teachers said they found that children often disagreed through misunderstanding, rather than having an alternative idea or strategy. Christine said they disagree “when they can’t explain their answer, or disagreeing but not able to back it up because they can’t”. Lizzie agreed and illustrated an incident in her classroom where children had a disagreement over a mathematical problem but she thought that they were disagreeing from a place of frustration rather than an opposing mathematical view: “I found that hard to manage. I needed to give them the language to disagree politely but I didn’t know where to start”. Lizzie made the point that it is so important for children to have the language of

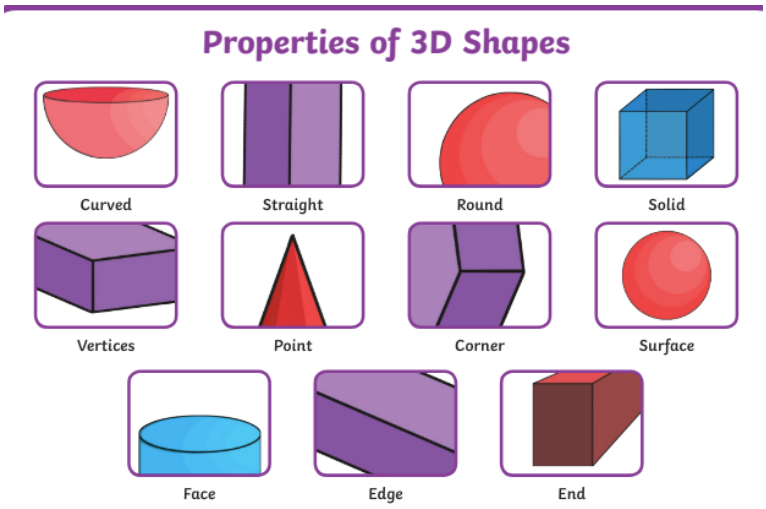
argumentation and justification but that she needed support with providing this language so that her pupils could argue and justify effectively and politely. While many teachers identified supports that they needed to implement Mathematical Discourse among children with EAL, one teacher shared an approach which she found useful to support children with EAL. Her contributions involving visual aids were presented in that section. Teachers need support with managing children's disagreements, arising out of language constraints.

Figure 2

Christine's Prompt Poster (Source: Twinkl)

Figure 3

Christine's Word Bank of 3D shapes (Source: Twinkl)



In summary, teachers in this group felt supported when they used visual aids, and had access to digital and bilingual materials in their classrooms to initiate and sustain Maths Talk. They found significant difficulty in dealing with the frustration of EAL learners, and the lack of available concrete resources and in making mathematical language- in particular higher ordered thinking skills like the naming of strategies- accessible to students who are developing proficiency in English. Teachers also felt like their own knowledge in naming strategies was a barrier to fully implementing Mathematical Discourse in their classrooms.

2: Teacher Knowledge

One teacher in particular who was observed in this research showed a strong knowledge of mathematical content knowledge during a Number Talks session. She was observed to have named strategies on the board as children made their contributions. She re-voiced their strategies and followed them with “oh you compensated, nice work” and then used scaffolding to encourage the children into eliminating some answers that couldn’t have be true “Mary said it couldn’t be 7, why is that?”.

Teachers in this study were observed to have used their knowledge of content and students to support their teaching. In another observation, a teacher was observed to use her students’ misconceptions as a teaching point during her lesson. She invited student answers and strategies as to how they had figured out 15+_= 21, including an Empty Number Line (ENL) strategy where the answer provided was 4. The teacher swiftly drew an ENL on the board with 15 on the left side and 21 at the end of the right side. She listened to students chiming in and saying that it couldn’t be 4, that 4 wouldn’t get you even as far as 20. The teacher tried 4, then 5 yet before she got to 6 the original student had interjected and changed his answer. This teacher showed knowledge of

her content and her students together. She knew why her student had arrived at 4 and expertly guided him towards the correct answer, while affirming his strategy by displaying it on the board.

Both teachers showed their specialised content knowledge and knowledge of content and students as they adeptly facilitated their Number Talks sessions, and their class moved fluidly between strategies.

Teachers also need support with Specialised Content Knowledge

Naming Strategies

This study finds that teachers' own knowledge of the content to be covered, including the names of the strategies that children communicated is something that they need support with when implementing Maths Talk in their classrooms. In the mind-map (included in Appendix G), teachers included "names of strategies" as something that they need support with when trying to implement Maths Talk in their classrooms.

One teacher said

> "I just don't know the names of the strategies so I feel a bit stuck with that. I want to say their strategy back to them, or write it on the board and say 'Oh that's a compensation strategy' or something like that, you know with revoicing? But apart from the basic ones, you know like counting on or tally marks or something, I don't know the names of them" (Lizzie).

In a different informal conversation, Sofia said something similar and asked for a book, or a recommendation of something to read that would help her name her pupils' strategies

> “the ones that are in the book are ok, you know, counting on and that, but I wish I could push them on a bit and name some strategies that would help them as they go up the school”. (Sofia)

This teacher also recorded in the mind-map when asked what she needed support with “where to go next (after addition and subtraction)” and “how to get there”. She needed support, having already implemented some Maths Talk in her classroom, with how to extend her own knowledge of the content and strategies. This knowledge of content and teaching that is needed will be explored in the next point.

Teachers needed support with their Knowledge of Content and Teaching:

Supporting higher-ability learners

Teachers felt like they needed support with working with children who have strong mathematical ability, and who challenged their own knowledge of the content. Mary and Sofia recounted working with a key pupil who had behavioural difficulties but who was a strong maths student:

> “He was willing to accept an answer once it was explained in its entirety in every part of every lesson and in every subject, he asked ‘why’ about everything but he was willing to accept an answer once it was explained literally and then would say ‘oh ok’” (Sofia).

Mary had worked with this student in a SET capacity and said: “Sometimes I’m challenged within my own ability, or you know, do have to use internet search tools about certain things to get the answer”. While this discussion centred around how children argue, and why they argue in maths, both teachers revealed that they need the support of internet search engines in order to answer their pupil in the most literal of terms.

"It's challenging, you'd need to have your wits about you, but once I have my phone I can look it up, and he will accept my answer. " (Jane)

This teacher found that searching things on her phone in the moment strengthened the level of discourse she had with her pupil. If she could answer his questions about content, he would desist from arguing and the lesson could progress. While her phone was a support, her knowledge of the content was challenged by his strong mathematical ability. She also needed support with how to cater for a high-ability learner.

Similarly, children who arrived from Ukraine, as previously mentioned, had strong computational mathematical skills, but parental expectations for Irish teachers to match the Ukrainian curriculum posed a difficulty for these teachers, and was something they needed support with. Mary remembered parents of the Ukrainian pupils presenting her with textbooks from their private school in Ukraine: "last year…to see if we could deliver certain similar lessons which obviously was beyond our expertise, but the maths were very much, very advanced. Think like division, in First Class!". Mary felt like the content that the parents expected her to deliver was, as she put it beyond her expertise, this was something she needed support with. As was also mentioned earlier in relation to EAL learners, their computational knowledge didn't match the level of language that the new entrants had, and this posed another challenge that teachers needed support with.

To summarise, teachers in this study felt supported in implementing Maths Talk when their specialised content knowledge and knowledge of content and students were well developed. When their specialised content knowledge was underdeveloped, they needed support like their example of naming strategies. Teachers also needed support with their knowledge of content and teaching, particularly when it came to high-ability learners. In order to upskill and read more, as

teachers suggested they might like to do, they needed the time to do it. Time was a strong theme in all of this research and will be presented thematically in the next section.

3. Supports needed arising from time constraints

When classroom observations took place, time was not observed to have been an issue for any teachers. However, these observations were planned events and teachers had allocated their lesson that day to the researcher. It is possible for this reason that time was not a factor during classroom observations.

Teachers feel supported by play time in younger class levels

Class level

Sofia found that teaching a lower primary class level enabled her to spend more time talking about maths with her class. Her class level is something that she perceived to be a support when implementing Maths Talk with her class. Lorraine agreed and spoke about her experience in the infant classroom. She elaborated on how the Aistear framework supported her with the time to implement Maths Talk in the classroom. Lorraine went on to describe an incident in her classroom where two children were comparing their pencils during a Literacy lesson:

> "It led to us doing a lesson on length. I told them we could come back to their pencils during Aistear later on and I would give them all of the measuring instruments. Later I got down on the floor and played with them, and could extend them from bigger and smaller than by throwing in all of that lovely language such as 'centimetres'. Because I had the time to do it!" (Lorraine).

Lorraine described how the Aistear framework allowed her to return to a topic that followed the children's interest and it gave her the time to engage in that mathematical discourse with them.

She found that having a younger class level with the support of the Aistear framework enabled her to implement Maths Talk in her classroom. Sofia, however, found that time was a negative factor in her experience, which will be presented next.

Teachers need support to overcome time constraints

Teachers expressed that they had a desire to spend time discussing mathematical concepts in detail with their pupils. This showed that they place value on time spent engaging in Mathematical Discourse in their classrooms. However, time was an issue for all teachers involved in this focus group.

> "(It's about) providing opportunities for the children to discuss more about their learning and maths, giving them opportunities to do that, you know, and give them time to do that aswell" (Christine)

Teachers also expressed difficulty with having the time to discuss and explain due to the constraints of having to finish the textbook, the length of time it took to hear all children give their answer, and the amount of time that is dedicated to explicit teaching in the older primary classes. Teacher comparisons of the time given to explaining and talking were trifold in this group; in SET, in the lower primary and the upper primary classes. When asked what percentage of the lesson is spent questioning and explaining strategies, teachers expressed difficulty with the division of responsibility for learning in light of the new curriculum and its recommendations to give more responsibility for learning to the pupils. Teachers' thoughts on the impact of listening to every child speak and experience ownership over their learning as a something they need support with, together with pressure to finish the workbook will be laid out next.

Time to listen as a support and as needing support

Time to listen to everyone's strategies was a negative factor in implementing Maths Talk in some teacher's classrooms. It took an excessive amount of time to get around to all of the children said Sofia:

> "it just takes so much time because if you have to listen to three different strategies, you're there for fifteen minutes. That is a big chunk of the maths lesson, and then, really only three children have spoken. It's a challenge in every lesson to try to hear every child."

Teachers in this group agreed that time given to listen to each child is a factor in the successful implementation of Mathematical Discourse in their classrooms. Sofia continued and suggested that planning for a Number Talks session with her class every day, helped her ensure that she gave adequate time to talking and explaining. "You could use up fifteen minutes and that's only one sum, so I have to plan for Maths Talk" (Sofia). Jane agreed and said she also plans for MT and that helps her to ensure that it is part of her lesson "I'd have planned for it, separate to my maths lesson, a number talks lesson even to make sure I got it done every day". Planning the Maths Talk, and allowing time for it every day, was a supportive factor that these teachers agreed helped them to implement Mathematical Discourse in their classrooms. However, pressure to finish the workbook, particularly in the older classes, hampered this process by taking up time that could be given to talk and discussion, as presented next.

The workbook as a support and as needing support

"That rush to finish the book, to get to the book sometimes" was the experience of one teacher who had previously taught third class. The group discussed the book rental scheme as a possible reason for publishers having such "busy" pages, "with reams of sums".

> "In third class, you spend that much time lining the page (of the copy) and putting things down on paper and you don't really get a chance to do a lot of explaining or talking with them (the pupils). It's tricky when you would rather spend the time talking but you are under pressure from the parents to get the book finished or used fully. I'd love just a blank copy!" (Jane).

Jane expressed that the pressure to finish textbooks and fill copies was a barrier to her implementing Maths Talk in her classroom and was something that she would like to overcome. Conversely, and in keeping with her thoughts on the lower class levels having more time, Sofia expressed a feeling of support with implementing Maths Talk in her classroom because the workbook she used took very little time to complete. She used it to consolidate learning at the end of her lesson she said, because if she relied solely on the textbook: "my lesson would be over in like, fourteen minutes" (Sofia).

4. Teachers feel supported by a Growth Mindset but need support with pupils' Maths Anxiety

Creating a culture where learning through errors are valued and the emphasis is on thinking and metacognitive skills, are factors that teachers in this group agreed support them in implementing a Maths Talk environment in their classes. They felt they needed support with helping children who experience negative emotions such as Maths Anxiety during Maths Talk lessons,

When asked if they felt that they had a MT environment and if so, how they got there, Christine answered "I do feel like I have a Maths Talk environment in my classroom" and "It's about creating that environment in the class where it's ok to get something wrong, it's about learning from

mistakes". She continued the discussion by describing how children can be anxious and upset if they don't get the correct answer: "They're so focussed on getting the right answer and if they don't get it they're distraught, so it's coming away from that.. and that's where the learning happens". Jane agreed and said "and when they get comfortable with it, they fly it then! It makes the lesson and the talk so much easier when they're not afraid". "Yes! Because they're not scared to get the wrong answer then sometimes", Lizzie concurred. Sofia also felt like she had a MT environment in her classroom and credited "not focussing on the answer" with creating such a culture when asked how she created a MT environment in her class. Teachers in this group agreed that creating a culture where errors are celebrated and it being ok to get something wrong, supported them in creating a Maths Talk environment in their classrooms. They suggested that they could do this by taking the focus away from the right answer. Opportunities to discuss mathematical strategies without fear of failure during Maths Talk and creating an emphasis on number facility over procedural fluency was something that teachers needed support with.

5. *How* teachers want to receive support

Throughout the observations, focus group and mind-map, teachers had strong positive reactions to opportunities of peer observation and time for professional conversations. The following subsection details the professional learning mechanisms teachers feel they need to develop Maths Talk.

Peer learning:

Teachers involved in this study agreed that peer-learning opportunities were preferable when learning more about how to implement Maths Talk in their classrooms. They enjoyed learning from and through each other. When asked how they would like to receive information and training on

implementing Maths Talk in light of the new curriculum, there were numerous mentions of and references to peer-learning and observations. In the focus group, teachers made statements such as:

> "I think peer-learning is great, just incredible" (Mary)
>
> "A chance to observe other people's practice, like simple games you can share together" (Mary)
>
> "If we go into each other's rooms, we'd learn something different" (Sofia)
>
> "When you were in college is different from when we were in college" (Jane)
>
> "To see you doing that compared to how I do them" (Christine)
>
> "I think we get a lot from watching other people teaching" (Lizzie)

Teachers in this group talked about going into each other's classrooms to observe maths lessons, and spoke about the benefits of doing so, not only to develop their knowledge of mathematical pedagogy, but for classroom management tips. They discussed how some of their college learnings would be different to their colleagues. Teachers in this group were trained in three different stages of the Irish curriculum, some in the 1971 Curriculum, some in the 1999 curriculum and a newly qualified teacher, who was completing the Droichead programme at the time of research. They displayed a willingness and a desire to learn from each other. Throughout the focus group, participants responded enthusiastically to each other with exclamations such as "Wow, what a great open question!" and "What are those Odd-One-Outs? I'd love to try them!" and "I'll send that on to you, it's no problem!". Teachers in this research were happy to upskill and they would like to do that through peer learning opportunities.

In-person, in-school training

Teachers involved in this study felt that their time was valued when professional development took part during school hours and was delivered in person. They discussed the *right to disconnect* especially in light of the increase in webinar based training. Teachers felt like this was a new phenomenon introduced in part due to the sub crisis in Ireland at the time of research and following the Covid-19 or "online" years. Teachers said

> "What about the right to disconnect?" (Jane)
>
> "The courses in Navan used to be great, during the day. Now they're all online. And most of them are in the evening. Probably because they can't get subs" (Mary)
>
> "I much prefer face-to-face training" (Christine)
>
> "Remember those Speech and Language training webinars? During the day? Someone came in to let us go and we did them in the SET room. That was great. I felt like my time was really valued" (Jane)

Teachers also spoke about the quality of CPD presentations. They discussed how memorable it was when the person delivering the course was knowledgeable and added their classroom experience or anecdotal evidence to the delivery of their courses. One teacher reminded another about a Number Talks workshop that they had gone to, together with the principal.

"Remember? In Navan, you, me and himself went. It was great. We came back and did it (Number Talks) the next day?" (Jane). Teachers in this focus group valued practical workshops, delivered by a person who had teaching experience themselves. They found that they connected more to the person and the content when it was delivered in this nature.

Summary of findings

From the thematic analysis of data gathered teachers clearly expressed supports that they felt they had, in implementing Maths Talk in their classrooms, and supports that they felt they needed. Teachers felt supported by visual aids and digital resources such as Translate Apps. They felt confident in their teaching when their content knowledge and knowledge of content and students was aligned with the children that they were teaching. They expressed satisfaction with things like having time to converse with children during play time, and when those children celebrated mistakes and kept trying. Conversely, teachers felt they needed support with resources to teach EAL learners, their specialised content knowledge as needed to name children's strategies. Pedagogical knowledge was also what teachers perceived to be needing support, such as how to adequately teach high-ability learners. Finally teachers expressed a desire to learn more about Maths Talk, and they would like to do this by observing each other, during the school day. A discussion of these findings as they relate to relevant literature is presented in the next chapter.

Chapter 5 Discussion and Conclusion

Introduction

This study sought to find teacher perceptions of the supports they have and/or need to implement Maths Talk in their classrooms. It was found that they feel supported by their teacher knowledge, adequate resourcing of classrooms and the positive mindsets of their students. Teachers felt they needed support when they didn't have the resources that they needed or when their content knowledge didn't match that of their students. The analysis of findings suggested that there were six themes that captured the supports that teachers felt they had and/or needed. This chapter presents a discussion of the findings as they relate to relevant literature.

1. EAL learners

Like the findings of Araujo et al. (2018), which found many EAL learners in American classrooms, Ireland also has a significant number of EAL students in their classrooms. Data from the 2022 Census in Ireland showed that there was an increase of 23% in people speaking languages other than English or Irish at home, representing approximately seven hundred and fifty thousand people in total. This correlates directly to the number of English Language learners in Irish primary school classrooms (CSO, 2023). As shown in the previous literature, children who are EAL learners are at a significant disadvantage in Irish classrooms, primarily because of their home language differing to that of the language of instruction (NEPS, 2020; Ní Raghallaigh, Smith & Scholtz, 2019). Teachers in this study felt supported by factors such as visual aids, and access to digital and bilingual materials when teaching EAL learners. They felt they needed support with the frustration felt by these EAL learners, the lack of available concrete resources and in general, making

mathematical language accessible to their EAL students. These findings will be discussed with reference to relevant literature below.

Teachers felt supported when they used Translate Apps and visual aids

Teachers in this study felt supported when they used digital resources such as Translate Apps and aids such as visual posters when teaching and including EAL learners in their Maths Talk classrooms. Christine in particular, was already using many of these tools, as recommended by August et al (2023). She had experienced what Hufferd-Ackles et al., (2004), Norén (2008), Trawick-Smith, DeLapp, Bourdon, Flanagan and Godina (2022) and Trawick-Smith et al. (2022) had advocated for, the children's home language being valued and respected. By her use of Translate Apps in particular, relationships in her classroom improved and children felt affirmed, similar to the findings of Lake and Besily (2019). It is reassuring to note that other teachers involved in the focus group expressed positive feelings towards her strategic use of resources and showed signs of wanting to learn more. All other teachers involved in classroom observations used mini-whiteboards with their classes, in order for children to visually support their explanations. These whiteboards led to widespread engagement in the lessons observed. This is supported by the work of Chapin et al.'s (2009) research which advocates for the use of visual strategies for increased engagement in Maths Talk.

Teachers felt they needed support with frustrated EAL students and lack of concrete, tangible resources

Teachers in the focus group expressed their difficulty in dealing with EAL learners feelings of frustration. They acknowledged the strong computational skills of some EAL learners, Ukrainian students in particular. However, teachers expressed dissatisfaction at the lack of support they felt

in helping these students to argue, justify and explain politely. Hufferd-Ackles et al.'s (2004) research endorsed these findings and said that having computational skills is not enough, that children need to have the language to explain their thinking. Similar to that of Bruun et al. (2015) and Moschkovich (2015) it was found that children need appropriate and specific mathematical language in order to participate in meta-practices like Maths Talk.

Lack of concrete resources was another factor that teachers felt they needed support with. They acknowledged that access to a wide and varied amount of materials was not commonplace in their experience. This concurs with the findings of Driscoll (2017) albeit in an Irish (and not Australian) context. In order for the New Primary Mathematics Curriculum (DE, 2023), access to and funding for concrete materials and resources should be made available for EAL and for all learners in order to support their access to Maths Talk.

In summary, teachers perceptions of what they felt supported by and needed support with were largely in line with relevant theory surrounding these factors. Some recommendations arising from this study include wider use of digital translation and bilingual technology, and for more adequate funding to be made available for resources.

2. Teacher Knowledge:

What supports do they feel they have?

Specialised Content Knowledge

In this study, teachers were observed to have been supported with their content knowledge in order to implement Maths Talk effectively in their classrooms. In the observation, one teacher showed her expertise in naming strategies for her students during a Number Talks session, which progressed the lesson and deepened the mathematical understanding of her class.

This is in line with significant research carried out in the area of teacher's content knowledge (Ball 2005, Ball et al., 2008, Delaney, 2005). Like Sfard and Avigail (2007) stated, the teacher leading a Maths Talk needs to be an "experienced interlocutor" (p.1) and this was an example of how it was observed in this research.

Knowledge of Content and Students

An earlier example detailed a teacher observed to have drawn the ENL on the board while using her student's misconception as a teachable moment for the rest of her class. This teacher showed expert knowledge of both mathematical content, and he student. She knew why the child had arrived at the wrong answer and endeavoured to use that mistake to teach the rest of the class. This teacher's moves are supported by the findings of Hourigan (2010) and Delaney (2008). She showed that she could think on her feet when faced with a wrong answer, while showing knowledge of both mathematics and teaching.

Teachers in this study found that their knowledge of mathematical content was a challenge when naming strategies that children communicated during Number Talks and other mathematical lessons. This will be discussed next and concurs with the aforementioned literature. Continuous professional development in mathematics is a strong theme in our research and is therefore a recommendation from this study. This professional development should be two-fold and include subject matter study as well as pedagogical knowledge development

What supports do they feel they need?

Specialised content knowledge

Although some teachers were observed to have been supported by specialised content knowledge, in the focus group, and during informal conversations, teachers in this research felt they needed support with naming strategies that children produced on the spot during lessons featuring Maths Talk, in order to effectively implement Mathematical Discourse in their classrooms. These findings echo what Hourigan (2010) found about subject matter knowledge and being able to respond in the moment, what and Dooley et al (2014) spoke about, having a profound knowledge of maths. Earlier findings noted that Smith et al. (2019) suggested splitting a maths lesson over two days. This would give teachers time to read what some students were working on in the first lesson, in order to prepare for the next day's lesson, and perhaps in advance of a whole class discussion.

Knowledge of content and teaching

Teachers in this case study referred to needing support with high-ability learners. They perceived both their knowledge of mathematical content, and how to teach students who have strong mathematical ability as a challenge. These perceptions are reinforced by the study by Hundeland et al., (2020) who found that being competent in creating opportunities for children to participate in mathematical discourse relates to Knowledge of Content and Teaching. Despite the small sample in this current case study, a substantial number of the same difficulties were noted as in the Hundeland et al. (2020) study. This is something that teachers felt they needed support with.

In order to support higher ability leaners, teachers themselves need to have both a strong knowledge of content and of mathematics pedagogical instruction (Hourigan, 2010). Although published research in an Irish context surrounding how teachers can best be supported in implementing Maths Talk is limited, it can be suggested that if teachers' own knowledge in how to

support higher ability learners, who are also English language learners is deepened, this will be a support to them. As noted by the teachers in this study, this is a timely issue with their Ukrainian students. Anecdotal evidence suggests that these pupils are strong computational maths students, but they face difficulty when discussing their answers and taking part in discussions, as was discussed earlier in relation to EAL learners. Further research is needed as to how to cater for these students best.

Summary

In summary, the work of knowledgeable instructors who are well-versed in their subjects is essential to school systems, and the ability of educators to effectively employ educational resources, evaluate students' progress, and make smart decisions regarding presentation, emphasis, and sequencing is largely dependent on their level of mathematical knowledge (Ball, 2005).

An interesting observation that arose out of both observation and focus groups was that teachers were observed to have been supported by their specialised content knowledge and their knowledge of content and students, however, their perceptions as discussed during the focus group revealed that they felt they also *needed* support with their specialised content knowledge as well as content and teaching. While it was true that different observations yielded different findings, it is also stands true that their perceptions may not be exactly in line with what they were observed to have done.

3. Supports felt or needed arising from time constraints

Time has been shown to be a major issue for teachers. Time to engage with children during mathematical discourse was a support that teachers in this study felt enabled them to implement Maths Talk in their classrooms. Conversely, the issues of time for CPD including professional conversations and time to incorporate discourse into their lessons because of pressure to complete textbooks, were major factors that teachers in this research felt they needed support with. The following is a discussion of the findings of this research as it relates to the above themes.

Teachers feel supported by: Time to incorporate Mathematics Discourse into lessons

The findings of this study revealed that teachers felt supported by the Aistear Framework within an infant class setting because it allowed them the time to engage in mathematical discourse with their pupils during play-time. Conversely, the Aistear (2009) document considers time to be a challenge in multiple aspects of its framework, including the conversations which they term to be a methodology: "the adult requires time to develop skills to encourage and enable children to share insights on their learning and development through talking. Can be time-consuming" (p. 102). Aistear is to be updated later in 2024 and going forward will be more applicable to early childcare settings, but will be aligned with the Primary School Framework (DE, 2023). As it stands, the perceptions of teachers in this study are different to the constraints noted in the Aistear framework.

Teachers need support with: Time to engage with children during mathematical discourse

It was found in this study that teachers needed support with time, with regards to listening to every child speak or make a contribution during the Maths Talk lesson.

The findings of Smith et al. (2020) are reaffirmed here, as their research had identified time as a two-pronged issue both running out of time, and having time to listen to student Maths Talk while keeping the rest of the class actively listening. This was certainly the case for teachers involved in this case study. However, Smith et al. (2020) said that teachers can engage the rest of the class by questioning the speaker in a way that captures everyone's attention. Our findings suggest that teachers need support with finding the time to hear everyone in their class contribute a strategy. One teacher referred to listening to three strategies taking a possible fifteen minutes. Smith et al. (2020) offered a solution for this which involved the teacher to making the lesson truly meaningful by purposefully selecting the work of a student to share with the class which contains "important mathematical ideas that advance the goals of the lesson" (p.143). They concluded therefore, that the aim for the teacher is not to hear a contribution from every student, rather to select students' with strategies that adhere to the objective of the lesson and instead, to make those contributions work as well as possible to the maths objective within the timeframe allocated.

Teachers need support with: Time constraints due to using/finishing textbooks

Teachers in this research felt bound by pressures from parents to complete textbooks that had been bought or rented from the school. They felt like the time taken to complete workbook pages (that were not necessarily aligned to their objectives) took away from time that could be spent engaging in mathematical discourse in the classroom. This concurs with the findings of Dooley et al (2014) who suggest that Cognitively Challenging Tasks are required in Irish classrooms, due to Irish Maths textbooks' over emphasis on procedural fluency. These teachers felt they could be supported by increased agency. Some teachers involved in this research believed the recent free book scheme introduced by the Irish Government in 2023 would not do much to solve this issue

either because schools will continue to employ a book rental scheme and teachers may still feel that they need to complete every page.

The INTO (2017) surveyed teachers in anticipation of the development of a new curriculum. Their findings were broadly in line with this research “Fewer textbooks allow for more teacher autonomy and allow for more diverse teaching and learning” (p.99). The INTO (2017) found that teachers felt strongly about textbooks, their use and efficacy which again, resonates with what this study found. Teachers surveyed by the INTO, however, felt that the school book rental scheme was positive, which participants in this research disagreed with, but that it needed to have a whole school approach in the interests of continuity. They also felt that content is not always aligned to the curriculum. Similar to the findings of this case study, the INTO (2017) survey also found that “teachers feel pressure to complete the textbooks in order to satisfy the expectations of parents” (p.99). Teachers in this study felt they need more support with exercising their agency in planning, with particular regard to textbook usage and completion. This is broadly in line with the INTO (2017) findings.

The evidence provided and discussed has shown that teachers in this study perceived pressure from parents to finish text books. They needed support with agency in their planning, which they found beneficial, and were optimistic that it would give them time to listen to all students.

They felt supported when they had agency under the Aistear framework and spent time playing with their class in a focused way. Incorporating the work of Smith et al. (2020) and Chapin et al. (2009) regarding productive discussion and talk moves would be beneficial for these teachers.

4. Classroom climate

A safe environment where errors are respected, and even celebrated was how teachers in this study described their ideal, Maths Talk classrooms. They found that when the environment of the classroom had a focus on strategic competence and was not answer-driven, they felt more supported in implementing Maths Talk in their classrooms. Studies such as that of Boaler (2022) and Dweck (2019) promote the idea of a *Growth Mindset* where mistakes are viewed as a challenge and as a motivator. Their findings concur with the findings of this case study.

A focus on strategic facility and conceptual understanding was another support that teachers in this study felt helped them create a positive environment in their Maths Talk classrooms. The work of Maloney et al. (2013) and Klee et al. (2022) strongly reaffirm these findings.

Educators contributing to this research felt they needed support with students feeling negative emotions such as Maths Anxiety. Central to their thoughts about how to help these students was to a place a focus on conceptual understanding, and to move away from an answer driven environment. Their perceptions are validated by the work of Chinn (2020), Boaler (2016, 2022), Klee et al. (2022) and Maloney et al. (2013).

It is important to note that there is some criticism of Growth Mindset theories, suggesting that mathematics cannot be developed by mindset alone (Nottingham and Larrson, 2018). However, the teachers in this study agreed that the climate of the classroom was one of a number of factors in achieving a supportive, Maths Talk, environment. It is imperative that teachers prioritise fostering a growth mindset and emphasise the significance of conceptual understanding to effectively implement Maths Talk in their classrooms. By doing so, they not only enhance students' engagement and critical thinking in mathematics but also create a supportive teaching

environment. This approach ensures that teachers feel encouraged and equipped to facilitate meaningful mathematical discussions, ultimately leading to improved student outcomes.

5. Teachers views on Continuing Professional Development:

Teachers in this study were asked *how* they would like to receive more information and training on implementing Maths Talk in their classrooms. They all agreed on learning from other colleagues and observing in classrooms. This is consistent with the findings of Kennedy (2016) who found that the most successful PD was delivered by someone who had taught themselves. These findings are in line with the NEPS (2020) document which mentions the enjoyment derived by teachers when working and learning from each other. Teachers involved in this research expressed a want to work in a community with their colleagues, their desire to do so in creating a discourse community in their classrooms is consistent with the findings of Dalby and Noyes (2022), Dooley et al. (2014), NEPS (2020), Lappan (1997) and Gibson and Brooks (2012) who advocated that teachers can benefit from peer learning opportunities and in contrast to the findings of Kennedy (2016).

Kennedy (2016) postulated that the most effective PD did not have a direct focus on subject content. Contrastingly, Hourigan (2010) also said that teachers can “address weaknesses through further personal study of particular concepts” (p. 4). In the findings of this case study, a teacher mentioned the effectiveness of a face-to face Number Talks seminar. She felt supported in implementing its content in her class the following day. The findings of this study show that teachers would like a focus on specialised content knowledge (Ball et al., 2008) which agrees with the earlier mentioned work of Shulman (1987) and Delaney (2005) and suggests continuous professional development in both content and pedagogical knowledge would be a support to

teachers in implementing Mathematical Discourse. They would like this training to be delivered in-person, preferably during school hours.

As Maths Talk is at the heart of the new Primary Mathematics Curriculum, implementing it as a new pedagogy is something that the teachers felt they would need to learn more about. They felt strongly that a supportive school and national level of training would be best served by face-to-face instruction and training during working hours. Teachers in this study felt that this would place value on their time and their right to disconnect. In order for this curriculum to be implemented successfully, the findings of Glenda Lappan (1997) apply "Effective supporting cultures for teacher learning and professionalism build on teachers' existing beliefs and knowledge, take into account the realities of teachers' school situations, and offer coherent and connected instruction and support over time" (p.207). In order to successfully implement reform, the final word goes to Lappan as she echoes our earlier findings: "Most educators will need extraordinary amounts of time" (p.233).

Conclusion

This research has illustrated the supports that teacher perceived they had and/or needed in order to implement Maths Talk in their classrooms. Insights gained include teachers' perceptions of support when they had access to physical resources such as visual aids and digital resources such as Translate Apps. Conversely, teachers sought support with practical constraints such as time management and adequate resourcing of classrooms. Teachers showed a positive disposition towards implementing Maths Talk in their classrooms but would like to develop their knowledge through ongoing professional development. Teachers identified CPD delivered face-to -face by skilled teachers during school hours, as well as opportunities for peer observation as how they would like to receive this training.

This case study has contributed to the field of research on teacher knowledge and type of professional development which some teachers would like to receive, while acknowledging how they would like to receive it. Specifically teachers perceptions included content knowledge and pedagogical knowledge as two areas to be improved upon in advance of the new curriculum. This is a timely study given the imminent introduction of the new Primary Mathematics Curriculum (DE, 2023) and the resultant teacher education which is to follow.

This research has provided more evidence that teachers will need adequate knowledge of both subject and pedagogy in order to successfully implement Maths Talk in their classrooms. Also identified were practical constraints such as time and resources which will be needed in order to create Maths Talk classrooms. These are largely outside of the control of the teachers involved but have implications for policy makers, both at national and school level.

Recommendations

This study makes a number of recommendations for policy, practice and future research, some of which are included in the table below.

Figure 4

Recommendations

For practice:	
	√ As there is limited research available on the effectiveness of using Translate Apps to support Maths Talk, a tool which teachers in this

	study reported using to support children who are EAL Learners, this study recommends that future research should be undertaken in the form of an experimental design study on the effectiveness of Translate Apps to support Maths Talk among children who are EAL learners.
<u>For policy</u>	
At national level:	√ As a result of finding that teachers need more time to listen to children engaging in Maths Talk, and more agency regarding textbooks, it is recommended that the distribution of time allocated to Numeracy as a core subject be adjusted to allow for this.
	√ Teachers in this research expressed a desire to upskill through in-person in-school trainings. Therefore, it is a recommendation of this research that CPD allocated by the Department of Education be provided during working hours, face-to-face.
At school level:	√ Similar to the previous point, teacher perceptions about CPD should be taken into account when designing in-school training.
	√ As a result of the finding that teachers need support with adequate resources there lies implications for Maths middle leaders arising out of this case study. Leaders should plan and advocate for the

	appropriate resources to be bought, organised and stored to make them accessible to all teachers in their school.
	√ For school management, some of the time allocated to planning should be reallocated to facilitate professional conversations.

Limitations

Due to the small sample size of this study, it has limited generalisability. However, the sample involved in this research was representative of a wide range of experience and initial teacher training. It provides very useful insights for the participating school, and it raises questions which may be of relevance to other schools as they plan for introducing new pedagogical approaches. Ethical considerations placed some constraints on *who* was observed in this study. It would also be interesting to observe student responses to teachers implementing Maths Talk.

Further Research

As discussed in Chapter 2, there is limited research available on the effectiveness of using Translate Apps to support Maths Talk, future research should be undertaken in the form of an experimental design study on the effectiveness of Translate Apps to support Maths Talk. Future research including the teachers involved in this study could centre around one aspect of Maths Talk, e.g. questioning.

To successfully implement the new mathematics curriculum, it is crucial that we support our teachers with necessary resources, training, and ongoing professional development. By investing in our educators and providing them with the tools and support they need, we can ensure that they are well-equipped to bring innovative pedagogical practices into their schools,

classrooms and to their students. Let’s commit to empowering our teachers, fostering a collaborative environment, and driving excellence in mathematics education for all our students.

Reference List

de Araujo, Z., Roberts, S. A., Willey, C., & Zahner, W. (2018). English learners in K–12 mathematics education: A review of the literature. *Review of Educational Research*, *88*(6), 879-919.

August, D., Barr, C., Carlson, C., Cárdenas-Hagan, E., Johnston, W. T., & Marken, A. (2023). A promising intervention designed to improve EAL learners' mathematics skills and associated academic language. *Bilingual Research Journal*, *46*(1–2), 117–141. https://doi-org.elib.tcd.ie/10.1080/15235882.2023.2225459

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational assessment*, *27*(3), 197-205.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide?.

British Educational Research Association (2018). Ethical guidelines for educational research. London: Author.

Boaler, J., Williams, C., & Confer, A. (2015). Fluency without fear: Research evidence on the best ways to learn math facts. *Reflections*, *40*(2), 7-12.

Boaler, J. (2022). *Mathematical mindsets: Unleashing students' potential through creative mathematics, inspiring messages and innovative teaching*. John Wiley & Sons.

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

Bruner, J. (1997). The culture of education. In *The Culture of Education*. Harvard university press.

Bruun, F., Diaz, J. M., & Dykes, V. J. (2015). The language of mathematics. *Teaching Children Mathematics*, *21*(9), 530-536.

Burgess-Allen, J., & Owen-Smith, V. (2010). Using mind mapping techniques for rapid qualitative data analysis in public participation processes. *Health Expectations*, *13*(4), 406-415.

Chapin, S. H., O'Connor, M. C., & Anderson, N. C. (2009). *Classroom discussions: Using math talk to help students learn, Grades K-6*. Math Solutions.

Chinn, S. (2020). *More trouble with maths: A complete manual to identifying and diagnosing mathematical difficulties*. Routledge.

Cohen, L., Manion, L., & Morrison, K. (2017). *Research Methods in Education*. Routledge.

Council, T. (2017). Droichead: the integrated professional induction framework. *Maynooth, Co. Kildare: Teaching Council*.

Dalby, D., & Noyes, A. (2022). Developing the mathematics teacher workforce in England's FE colleges: towards a 'communities of practice' strategy. Research in Post-Compulsory Education, 27(3), 413-435.

Delaney, S. (2005). Mathematical professional development for primary teachers: How have we got here? Where can we go? Where should we go? In S. Close, D. Corcoran & T. Dooley (Eds.), Proceedings of first national conference on research in mathematics education (pp. 235–249). Dublin, Ireland: MEI.

Delaney, S., Ball, D. L., Hill, H. C., Schilling, S. G., & Zopf, D. (2008). “Mathematical knowledge for teaching”: Adapting US measures for use in Ireland. *Journal of mathematics teacher education*, *11*, 171-197.

Delaney, S. (2010). Knowing what counts: Irish primary teachers’ mathematical knowledge for teaching. Dublin, Ireland: Marino Institute of Education/DES.

Driscoll, K. (2017). Primary School Mathematics Leaders' Views of Their Mathematics Leadership Role. *Mathematics Education Research Group of Australasia*.

Department of Education and Skills (2011) National Strategy: Literacy and Numeracy for Learning and Life 2011-2020

Department of Education and Skills (2010). Incidental inspection findings 2010: a report on the teaching and learning of English and mathematics in primary schools.

Department of Education (2022) Primary Curriculum Framework for Primary and Special Schools. Dublin. NCCA.

Department of Education (2023) Primary Mathematics Curriculum for Primary and Special Schools. Dublin. NCCA.

Dooley, T., Dunphy, E, & Shiel, G. (2014). Mathematics in Early Childhood and Primary Education (3–8 years). Research Report 17. Dublin: National Council for Curriculum and Assessment. Accessed at http://ncca.ie/en/Publications/Reports/NCCA_Research_Report_18.pdf

Dweck, C. S. (2019). The choice to make a difference. *Perspectives on Psychological Science*, *14*(1), 21-25.

Gaffney, M., & Faragher, R. (2010). Sustaining Improvement in Numeracy: Developing Pedagogical Content Knowledge and Leadership Capabilities in Tandem. *Mathematics Teacher Education and Development*, *12*(2), 72-83.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for research in mathematics education*, *21*(1), 33-46.

Hourigan, M. (2010). Mathematics subject matter knowledge (SMK) for teaching at primary level: How much is enough? University of Limerick. NCE-MSTL

Fearnley, C. J. (2022). Mind mapping in qualitative data analysis: Managing interview data in interdisciplinary and multi-sited research projects. *Geo: Geography and Environment*, *9*(1), e00109.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Gibson, S. E., & Brooks, C. (2012). Teachers' perspectives on the effectiveness of a locally planned professional development program for implementing new curriculum. *Teacher Development*, *16*(1), 1-23.

Government of Ireland (2024) Ireland's Literacy, Numeracy and Digital Literacy Strategy 2024-2033: Every Learner from Birth to Young Adulthood. Department of Education. Ireland.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*, *2*(163-194), 105.

Handal, B., & Herrington, A. (2003). Mathematics teachers' beliefs and curriculum reform. *Mathematics education research journal*, *15*(1), 59-69.

Harrison, H., Birks, M., Franklin, R., & Mills, J. (2017, January). Case study research: Foundations and methodological orientations. In *Forum qualitative Sozialforschung/Forum: qualitative social research* (Vol. 18, No. 1).

Hufferd-Ackles, K., Fuson, K. C., & Sherin, M. G. (2004). Describing levels and components of a math-talk learning community. *Journal for research in mathematics education*, *35*(2), 81-116.

Hundeland, P. S., Carlsen, M., & Erfjord, I. (2020). Qualities of mathematical discourses in kindergartens. *ZDM*, *52*, 691-702.

Irish National Teachers Organisation (INTO). (2017) Primary School Curriculum: Have your say. Discussion Document and Proceeding of the Consultative Conference on Education, 2015. Dublin. INTO

Kazemi, E. and Hintz, A. (2014) Intentional Talk: How to Structure and Lead Productive Mathematical Discussions, Stenhouse Publishers.

Kennedy, E., Shiel, G., French, G., Harbison, L., Leahy, M., Ó Duibhir, P., & Travers, J. (2023). Towards a new literacy, numeracy and digital literacy strategy: A review of the literature. Department of Education. Ireland.

Kennedy, M. M. (2016). How does professional development improve teaching?. *Review of educational research*, *86*(4), 945-980.

Klee, H. L., Buehl, M. M., & Miller, A. D. (2022). Strategies for alleviating students' math anxiety: Control-value theory in practice. *Theory into Practice*, *61*(1), 49-61.

Lake, V. E., & Beisly, A. H. (2019). Translation apps: Increasing communication with dual language learners. *Early Childhood Education Journal*, *47*, 489-496.

Lappan, G. (1997). The challenges of implementation: Supporting teachers. *American Journal of Education*, *106*(1), 207-239.

Lortie, D. (1975). School teacher: A sociocultural study. *Borg, M.(2004)" The apprenticeship of observation." ELT Journal*, *58*(3), 274.

Loewenberg Ball, D., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special?. *Journal of teacher education*, *59*(5), 389-407.

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *All Ireland journal of higher education*, *9*(3).

Maloney, E. A., Schaeffer, M. W., & Beilock, S. L. (2013). Mathematics anxiety and stereotype threat: shared mechanisms, negative consequences and promising interventions. *Research in Mathematics Education*, *15*(2), 115-128.

Manohar, N., Liamputtong, P., Bhole, S., & Arora, A. (2017). Researcher positionality in cross-cultural and sensitive research. *Handbook of research methods in health social sciences*, 1-15.

Moschkovich, J. N. (2015). Scaffolding student participation in mathematical practices. *Zdm*, *47*, 1067-1078.

National Council for Curriculum and Assessment (Ireland). (2009). *Aistear: The early childhood curriculum framework*. NCCA.

NEPS (2020) Maths Support 2020- A Good Practice Guide for Teachers 2020. Dublin . The Stationary Office.

Ní Raghallaigh, M., Smith, K. M., & Scholtz, J. (2019). *Safe haven: The needs of refugee children arriving in Ireland through the Irish refugee protection programme: An exploratory study*. Children's Rights Alliance.

Nottingham, J., & Larsson, B. (2018). *Challenging mindset: why a growth mindset makes a difference in learning–and what to do when it doesn't*. Corwin Press.

Norén, E. (2008). Bilingual students' mother tongue: a resource for teaching and learning mathematics. *Nordic Studies in Mathematics Education*, *13*(4), 29-50.

Peterman, C. J., & Ewing, J. (2019). Effects of movement, growth mindset and math talks on math anxiety. *Journal of Multicultural Affairs*, *4*(1), 1.

Prendergast, M., Harbison, L., Miller, S., & Trakulphadetkrai, N. V. (2019). Pre-service and in-service teachers' perceptions on the integration of children's

literature in mathematics teaching and learning in Ireland. *Irish Educational Studies*, *38*(2), 157-175.

Rooney, D., & Boud, D. (2019). Toward a pedagogy for professional noticing: Learning through observation. *Vocations and Learning*, *12*(3), 441-457.

Rost, F. (2021). Q-sort methodology: Bridging the divide between qualitative and quantitative. An introduction to an innovative method for psychotherapy research. *Counselling & Psychotherapy Research, 21*(1), 98–106.

Sfard, A. (2007). When the rules of discourse change, but nobody tells you: Making sense of mathematics learning from a commognitive standpoint. *The journal of the learning sciences*, *16*(4), 565-613.

Sfard, A. (2012). Introduction: Developing mathematical discourse—Some insights from communicational research. *International Journal of Educational Research*, *51*, 1-9.

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

Smith, M. S., Bill, V., & Sherin, M. G. (2020). The five practices in practice: Successfully orchestrating mathematics discussions in your elementary classroom. *Reston, VA: National Council of Teachers of Mathematics*.

Stuckey, H. L. (2015). The second step in data analysis: Coding qualitative research data. *Journal of Social Health and Diabetes*, *3*(01), 007-010.

Sztajn, P., Heck, D. and Malzahn, K. (2020). Activating Math Talk, SAGE Publications.

Sykes, G. (1996). Reform of and as professional development. *Phi delta kappan*, *77*(7), 464.

Thamarana, S. (2016). Role of E-learning and Virtual Learning Environment in English language learning. *Teaching English Language and Literature: Innovative Methods and Practices, ELTAI Tirupati*, 61-62.

The Teaching Council. (2017). Droichead: The Integrated Professional Induction Framework. Dublin. Teaching Council of Ireland.

Trawick-Smith, J., DeLapp, J., Bourdon, A., Flanagan, K., & Godina, F. (2023). The Influence of Teachers, Peers, and Play Materials on Dual Language Learners' Play Interactions in Preschool. *Early Childhood Education Journal*, *51*(5), 863-873.

Wahyuni, D. (2012). The research design maze: Understanding paradigms, cases, methods and methodologies. *Journal of applied management accounting research*, *10*(1), 69-80.

Yin, R. K. (2009). How to do better case studies. *The SAGE handbook of applied social research methods*, *2*(254-282).

Appendices

Appendix A Letter to Principal and Board of Management

Dear _____,

I hope you are well. I am writing to you because I am looking for your help in relation to research I am carrying out in Marino Institute of Education as part of a Master's Degree in Education. I am interested in researching how teachers feel they are or can be supported in implementing Maths Talk in their classrooms, in relation to its inclusion in the new Primary Mathematics Curriculum.

As part of this Case Study I would like to briefly observe 1st and 2nd Class teachers teaching a maths lesson, in their classrooms, followed by a Focus Group including the SET teachers that work with these classes. The purpose of the observation is to establish what level of Maths Talk is already in place in classrooms. I will use an observation document modelled on a research based rubric to complete this observation. The focus group will be organised around data collected from the initial observation and is hoped to establish how teachers feel they are supported, or could be supported in implementing Maths Talk in their classrooms.

If this is agreeable to you, please indicate this on the additional sheet and return it.

I have received ethical clearance from Marino Institute ethics committee. Any information collected will be retained for the duration of the research period only and then destroyed in accordance with Marino's data retention schedule. Your name or the name of the school will not be published and candidates can opt out at any point of the research should they so wish. If you

have questions about any aspect of the research I can be contacted at the email address (XXXX) or my supervisor (XXXX0 at (XXXX).

Kind regards,

XXXXX

Appendix B Participant Consent

January 2024

Dear Teacher,

I am writing to ask for your help with a case study that investigates mathematical discourse. The research project involves learning more about how you feel you are or could be supported in implementing Maths Talk in your classroom.

There are two parts to the study: (i) observation of a maths lesson and (ii) a focus group. The observation would be of a regular maths lesson, during school time. I would like to use observation notes of the lesson to study how teachers facilitate Maths Talk in their classrooms and what they perceive the challenges to be. In total it would take between 30 and 40 minutes. You are under no obligation to agree to be observed and can withdraw consent at any time, with no explanation necessary.

For the second and final part of the research, I would like to facilitate a focus group to discuss with you and our colleagues some of the themes that arise during the observations. I am also interested in your experience of maths discourse and talk during your teacher training and your teaching career to date. The focus group would last for 60 minutes or less and it would be recorded on audiotape. It will take place after school on a day that is convenient for you.

I hope you will be willing to participate because your responses are important and a valued part of the study. Your participation will remain strictly confidential. Your name will not be attached to any of the data you provide. You are welcome to discontinue participation in the study at any time, should you wish to do so. The risks of participation in the study are very low and of a social or reputational nature. While every effort will be made to ensure your identity is protected (data storage on a password-protected personal computer), there is a chance, for example, that someone who hears the audio may recognise you.

However, the audio will be kept in a secure location or on an encrypted device without your name attached to it. The audio will be retained only for the purposes of the current study. Once the study is completed, the audio will be destroyed on the basis of the schedule outlined in the Institute's data retention schedule. If you would like more information on how long the audio data will be retained for, please don't hesitate to contact me directly. There are no risks or direct benefits in completing the questionnaire or participating in the focus group. You will be asked to sign forms (below) indicating agreement to participate in the different parts of the study.

If you agree to participate please contact me in one of the following ways: email: (XXXX)

or phone (XXXX). If you are willing to participate, it would help me greatly to know this as soon as possible so that your participation can begin as soon as possible.

Your participation in this project is sincerely appreciated. I understand that your time is valuable.

Thank you for volunteering to participate in this research. Should you have questions regarding your participation, please contact .You may also contact my advisor for the project, (XXXX) at (XXXX).

This study has been considered from an ethical perspective by the Marino ethics in research committee. Should you have any questions or concerns about the ethical approval or conduct of this study, please contact MERC@mie.ie

Yours faithfully,

XXXXXXXXX

You will be given a copy of this information to keep for your records.

Statement of Consent:

Please read the questions below and indicate whether or not you would be willing to participate in the study as described.

Do you consent to participate in the study by taking part in the observation?	Yes	No
Do you consent to participate in the study by taking part in the observation?	Yes	No
Do you understand that you can withdraw from the study at any time and without reason?	Yes	No

Signature:_____ Date: _____

Signature of Investigator:_____ Date: _____

Appendix C Participant Information

January 2024

Information for Participants:

Background:

- As part of a Masters Degree in Education, I am interested in researching how teachers feel they are or can be supported in implementing Maths Talk in their classrooms.
- As the new Primary Mathematics Curriculum is the first time that Maths Talk has been explicitly included in an Irish Curriculum, I am particularly interested your previous experience of Maths Talk during your initial teacher training.

What am I hoping to do?

- As part of this Case Study I would like to briefly observe 1st and 2nd Class teachers teaching a maths lesson, in their classrooms, followed by a Focus Group including the SET teachers that work with these classes. The purpose of the observation is to establish what aspects of Maths Talk is already in place in classrooms. I will use a research based observation document to complete this task. Although children will be present and will participate in the lesson as normal, the focus of the observation is on the teacher's role and not on the child's participation.
- The focus group will be organised around data collected from the initial observation and it is hoped to establish how teachers feel they are supported, or could be supported in implementing Maths Talk in their classrooms.

What is your role?

- To be observed, teaching a maths lesson, in your classroom.
- To participate in a Focus Group, after school.

What will happen to the data?

- Your identity will remain completely anonymous. Your name will be replaced by a pseudonym and will not be attached to any information I collect. These observations not be used by anyone other than the qualified researcher working on this study. The data will be kept in a locked cabinet and on a personal password protected computer.
- I have received ethical clearance from Marino Institute ethics committee. Any information collected will be retained for the duration of the research period only and then destroyed in accordance with Marino's data retention schedule. Your name or the name of the school will not be published. If you have questions about any aspect of the research I can be contacted at the email address XXXX or my supervisor XXXX at XXXX.

***IMPORTANT* candidates can opt out at any point of the research should they so wish, with no explanation necessary**

For more information about the study please contact XXXX or supervisor XXXX

This study has been considered from an ethical perspective by the Marino ethics in research committee. Should you have any questions or concerns about the ethical approval or conduct of this study, please contact MERC@mie.ie

Yours sincerely,

XXXXXX

Appendix D Information Sheet (Parents)

January 2024

Information for Parents/Guardians:

- Your child's teacher has agreed to participate in a research study about Maths Talk and discussion. The study looks at how teachers can be supported to facilitate Maths Talk in their classrooms.
- As part of their participation in the study, your child's teacher will observed teaching a maths lesson in your child's class.
- Although your child will be present and will participate in the lesson as normal, the focus of the observation is on the teacher's role and not on the child's participation.
- no information will be collected about any children in the class for this study as the focus of the observation is on the teaching and not the learning.

For more information about the study please contact XXXX or supervisor XXXX

This study has been considered from an ethical perspective by the Marino ethics in research committee. Should you have any questions or concerns about the ethical approval or conduct of this study, please contact MERC@mie.ie

Yours sincerely,

XXXXX

Appendix E Adapted Observation Tool (together with completed example)

(Adapted) Observation Tool

Questioning:	**Occurrences:**	**Example of phrasing used:**
Teacher is the only questioner		
Teacher invites student questions		
Teacher prompts student to student Maths Talk		
Teacher uses follow up questions about methods		
Teacher prompts students to explain their answer, strategy or thinking		
Teacher asks open ended questions		
Teacher asks probing questions		

Explaining Mathematical Thinking:	**Occurrences:**	**Example of phrasing used:**
Teacher elicits answers that involve student thinking and/or strategies		

Teacher elicits answer based/focused questions		
Teacher probes student thinking		
Teacher fills explanations themselves		
Teacher probes for math thinking		
Teacher probes deeply for math thinking		
Teacher is open to and eliciting strategies		
Teacher facilitates justification and defence of answers		
Teacher scaffolds student thinking, encouraging complete explanations		
Teacher stimulates children to think more deeply		

Source of mathematical ideas:	**Occurrences:**	**Example of phrasing used:**
Teacher is telling / showing children how to do maths		

Ideas are primarily presented by the teacher		
Teacher elicits some student ideas		
Teacher does some probing to elicit student ideas		
Teacher acknowledges student ideas (without exploring)		
Teacher follows up on and builds upon student explanations		
Teacher uses student errors comfortably as an opportunity for learning		
Teacher facilitates student ideas guiding the direction of the lesson		
Teacher allows for, and places value upon interruptions during explanations		
Teacher uses student ideas for mini extension lessons		

Responsibility for learning:	**Occurrences:**	**Example of phrasing used:**
Teacher repeats student responses		
Teacher verifies students answers or shows correct methods		
Teacher promotes passive listening		
Teacher alone gives feedback		
Teacher begins to set up structures to facilitate students listening to/helping other students		
Teacher shifts responsibility for understanding ideas of others-to the students		
Teacher elicits agreement (or disagreement) from students about each others' ideas and / or strategies		
Teacher elicits revoicing and/or alternative strategies		
Teacher supports students clearing up misconceptions about others' work		

Example of completed table:

Teacher prompts students to explain their answer, strategy or thinking	////	Let's take some thinking time!
Teacher asks open ended questions	/	Can you tell me how you figured that out?
Teacher asks probing questions	/	Can you help me? (reference to figuring something out)

Appendix F Focus Group Questions

1. Where did you first hear about Maths Talk? What do you know about it?
2. Do you feel like you have a MT environment in your classroom or lessons? How did you get to this point?
3. How do you plan MT in your lessons, or does it just happen?
4. I saw a number of higher ordered thinking skills incorporated in your lesson. Can you see benefits to children arguing, justifying, explaining?
5. How do you mobilise these benefits? Are they evident at any other point in the day?
6. Do you ever see children argue their point in maths lessons?
7. If you think about the children who argue in maths (without naming names), do they argue in ways that are similar or ways that are different?
8. Are classes that involve MT any more enjoyable for you as the teacher?
9. What fraction of each lesson do you think is spent on questioning and explaining strategies?
10. 'PLAY AND PLAYFUL EXPERIENCES LEND THEMSLEVES TO CHILDREN TAKING OWNERSHIP AND RESPONSIBILITY FOR THEIR OWN LEARNING…'
    The new curriculum refers a lot to children taking responsibility for their own learning, Thinking about maths in particular, can you discuss how this would be possible in a lesson?

    *Finish with a group mind-map asking "Are there any supports you feel you would like to advance your use of Maths Talk? What are those? Where would you like to get training from? What would you like to know more about?"

Appendix G Mind-Map completed by participants

Appendix H Example of coding

"They just love that in my class where they have to, you know, pick which is the odd one out and justify it"	
"It generates lots of talk in class" (Odd one out)	Observing metacognition makes classes that involve mathematical discourse more enjoyable

Appendix I Ethical Approval

Declaration by All Proposers:

I have read and understood Marino Institute of Education's policy on ethics in educational research: and the Trinity College Dublin, the University of Dublin Good Research Practice Policies:

I declare that the details above reflect accurately my research proposal and I undertake to seek updated approval if substantive changes are proposed after this submission. I have consulted an authoritative set of educational research guidelines.

Signed: **Date: 07/01/24**

(Students Only) My proposals are based on consultation with my supervisor(s).

Signed: **Date: 07/01/24**

Supervisor's Signature: (**Student Proposal Only**, first supervisor only if there are two)

Signed: **Date: 09/01/2024**

In instances where supervisors feel that their specialised expertise may be important information for the MERC to take into account (e.g.in relation in researching highly sensitive areas such as trauma/abuse), please submit an additional page with any relevant information.

Final Approval Signed-Off by Research Ethics Committee

Signed: **Date: 09/01/2024**
