Title:
An Exploration of the Implementation of a Mathematics Dynamic Assessment with Pupils Experiencing Mathematics Difficulties in the Irish Education System using Yin's Case Study Methodology

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A thesis submitted to the Department of Educational Psychology, Inclusive and Special Education, Mary Immaculate College, in partial fulfilment of the requirements for the Degree of Professional Doctorate in Educational and Child Psychology (DECPsy)

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Abstract

Aims: The current research project aims to explore the implementation of a dynamic assessment of curriculum-based mathematics tasks in the Irish primary school context and address the question of how this process can support a student with maths difficulties. The study embraces a broad conceptualisation of dynamic assessment considering how this process may reveal psychological constructs in the zone of proximal development (Vygotsky & Cole, 1978), and how this process may improve propensity to learn by targeting deficient cognitive learning functions in accordance with the theory of structural cognitive modifiability (Feuerstein et al., 1991).

Methods: A multiple case study design (a pilot and 2 cases) using Yin's (2009) methodology was employed. Each case comprised of a triad of a child exhibiting maths difficulties, the class teacher and the special education teacher. Case propositions that structured the design and analysis are based on Vygotsky's zone of proximal development and Feuerstein's theory of structural cognitive modifiability.

Analysis: Qualitative data was obtained in the form of initial assessment and error pattern analysis, transcribed video recordings of dynamic assessment sessions, and semi-structured interviews with the pupil and teachers. Thematic analysis was used to identify relevant domain general and specific learning functions. Pattern matching analysis was used to identify patterns within the data consistent with those predicted by the theories of the ZoPD and SCM.

Results and Implications: Results suggest that the implementation of a mathematics dynamic assessment procedure can identify domain general and specific constructs that are in development. Moreover, patterns of empirical data align with the theory of SCM and suggest that by targeting deficient learning functions through the implementation of mediated learning experiences, mathematics attainment can be improved. These findings have implications for schools consistent with national guidelines for assessment (NCCA, 2008). The implications of these findings for EPs are dependent on the extent to which this process meets a need for schools and the number of sessions required to produce significant and lasting improvements.

Declaration

The work has not previously been accepted for any degree and is not being concurrently submitted for any degree.

This research is being submitted in fulfilment of the requirements of the Doctorate in Educational and Child Psychology.

I hereby declare that I am the sole author of this thesis. Where the use has been made of other people, it has been fully acknowledged and referenced.

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Name: Seamus Cunniffe

Signature:__________________________________

Date: 13th May 2024

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List of Abbreviations

DA	Dynamic Assessment
MDA	Mathematics Dynamic Assessment
ZoPD	Zone of Proximal Development
SCM	Structural Cognitive Modifiability
SESS	Special Education Support Service
LNLL	Literacy and Numeracy for Learning and Life
NCCA	National Council for Curriculum and Assessment
NEPS	National Educational Psychology Service
EP	Educational Psychologist
ANS	Approximate Number System
PISA	Programme for International Student Assessment
GOI	Government of Ireland

1. **Introduction**

The current thesis is a qualitative exploration of the implementation of a mathematics dynamic assessment in the Irish primary school context. The empirical investigation involves the use of case study methodology (Yin, 2009) to explore how dynamic assessment can be used to support a pupil exhibiting mathematics difficulties. This chapter introduces the current thesis by briefly outlining and discussing broad contextual factors that relate to the area of research. A brief outline of the following chapters is then provided. The introduction concludes by alluding to the philosophical assumptions and interpretive framework adopted by the researcher that informs the current research design. Consideration is also given to personal and professional interests that motivated the selection of this research topic and how this positionality affects the research design and analysis.

1.1. National Policy relating to Mathematics Education.

This research is relevant in the domain of primary mathematics education and is conducted at a time of significant change on a national level. Of note, the research is conducted following the culmination of the national *Literacy and Numeracy for Learning and Life 10-year strategy* (Department of Education and Skills, 2011), which detailed strategies to evaluate and improve national levels of literacy and numeracy. The research is also being conducted at a time when a revised mathematics curriculum is being introduced to all primary schools (National Council for Curriculum and Assessment, 2023). The new curriculum succeeds the old curriculum implemented in schools since 1999 (Government of Ireland, 1999). Being one of the oldest standing curricula in Europe at the time of its revision, an evaluative report from the National Council for Curriculum and Assessment suggested progression from the old curriculum ought to place a greater emphasis on the social and collaborative aspects of the learning process consistent with Vygotskian teachings (NCCA, 2016). The new curriculum was drafted in consultation with teachers, children, and parents and places a greater emphasis on the facilitation of inquiry based learning and problem solving through promoting playfulness, creativity and collaboration (NCCA, 2023).

1.2 Educational Psychology Practice in Ireland.

The role of the educational psychologist is a central component in this research inquiry. In Ireland this role has changed over the last number of years particularly with the introduction of the new allocation model in 2017 (Department of Education and Skills, 2017). This model gives schools more autonomy over the use of their allocated resources. Educational psychologists no longer gatekeep access to reasonable accommodations for certificate examinations or Irish exemptions as detailed in subsequent circulars (e.g. Department of Education, 2019).

The statutory educational psychology service is provided to schools by the National Educational Psychology Service (NEPS) established in 1999 as a subsidiary of the Department of Education following extensive advocation for such a service by the Psychological Society of Ireland (Swan, 2014). Since its inception the NEPS has aligned with a consultative model of service delivery in line with international best practice and works collaboratively with other department subsidiaries such as the National Council for Special Education (Crowley, 2007; National Educational Psychological Service, 2020). Educational psychologists are also still engaged with direct casework in schools. Presenting concerns for children which are the focus of assessment and intervention range from social/emotional needs to learning difficulties (National Educational Psychological Service, 2020)

1.3 Thesis Structure

Following this introductory chapter, Chapter 2provides context to the thesis by overviewing literature and defining key concepts related to numeracy development, mathematics education in Ireland, the role of the educational psychologist and dynamic assessment. Chapter three consists of a systematic review of literature exploring the implementation of mathematics dynamic assessment procedures in primary school samples. The synthesis and analysis of this literature identifies a lack of published qualitative data exploring the efficacy and utility of an individualized approach to dynamic assessment of mathematics tasks. These findings inform the empirical research question.

The empirical investigation is detailed in chapter 4 outlining the design, procedure and analytic techniques used in the investigation of how mathematics dynamic assessment can be used to support students in Irish primary schools. A multiple case study design with a pilot and two case studies chosen for literal replication is overviewed (Yin, 2009). An overview of a dynamic assessment with each of the three recruited pupils comprising of two, hour-long flexible interviews or dynamic interactions is provided. These assessment sessions were videoed and transcribed as the main data source for analysis. The findings of the study are then presented for both cases individually followed by a cross-case synthesis and discussion. Finally, the fifth chapter is a critical review and impact statement which provides an evaluation of the methodological and design components of the research. The contribution of this research to literature in this area is discussed followed by a consideration of the implication of the research to educational psychology practice in Ireland.

1.4. Philosophical Assumptions and Interpretive Framework

A post-positivist interpretive framework underlies the current study and is consistent with the design and methodology employed. Post-positivism supports a logical and rigorous method of data collection consistent with the ontological position that there exists an objective reality (Rogers & Willig, 2017). This approach aligns closely with quantitative approaches to research and thus it is suggested that an adoption of this framework in qualitative analysis is often done by researchers with quantitative backgrounds (Cresswell & Poth, 2018).

A traditional positivist stance in research suggests the interpretation of the researcher can be negated by use of purely quantitative techniques and statistical analysis while conversely a relativist paradigm embraces the researcher's perception and bias in qualitative data as an inseparable component (Clark, 1998; Rogers & Willig, 2017). The post-positivist researcher embraces aspects of each of these approaches by striving to measure an objective reality while conceding that measurement is influenced by various biases. To combat these biases, the post-positivist researcher often gains data from multiple sources and triangulates evidence to approximate objectivity (Rogers & Willig, 2017). The current investigation strives for objectivity by comparing the researcher's analysis of the videoed mathematics dynamic assessment sessions with accounts of the process reported by the pupils and teachers through semi-structured interviews. Coded data is also subjected to an inter-coder reliability analysis. Moreover, hypothesis testing that is consistent with a post-positivist approach takes the form of theoretical propositions in the current study (Clark, 1998; Yin, 2009). The testing of theoretical propositions is central to Yin's outlined case study methodology (2009), which portrays congruency between philosophical underpinnings and current research design.

1.5. Researcher's Positionality and Other Biases

Consistent with a post-positivist philosophy it is assumed that researcher positionality inevitably affects the data collection process and to a greater extent the interpretation of the data along with other sources of bias (Cresswell & Poth, 2018). Biases introduced in this investigation involve the use of theory-laden instruments. The current investigation involves a deductive thematic analysis framed by checklists used to support coding (Lauchlan, 2012), which are consistent with the theories of structural cognitive modifiability (Feuerstein et al., 1991), and the zone of proximal development (Vygotsky & Cole, 1978). The interpretation of the data on the part of the researcher is embedded in a broader value stance that advocates for the importance of inclusion, use of a strengths-based approach to assessment, and the importance of a collectivist culture in education.

1.6. Personal and Professional Interest.

This thesis topic arose as the result of professional and personal interest. Consultation with special education teachers in various placement experiences, indicated that numeracy was a domain that teachers require further support in, both in assessment and intervention. This observation is supported by a scoping review of published guidelines by the department of education that highlights the imbalance in resources allocated to literacy as opposed to numeracy (*NEPS Resources and Publications*, 2019). One central document is published to provide support to teachers in this domain (*Maths Support*, 2020). Moreover, the Math Support Guide: A good practice guide for teachers (NEPS, 2020), is already over three years old. The investigation is timely in this regard as teachers are revising pedagogical approaches to cultivating mathematical understanding while preparing to implement a new curriculum with pupils (National Council for Curriculum and Assessment, 2023).

1.7. Conclusion

This introduction has given an indication of the scope of the inquiry of the current project which relates to mathematics education and dynamic assessment. This introduction has also situated the investigation within relevant broader contextual factors which include the resources available for numeracy support in Irish schools, the imminent implementation of a new mathematics curriculum and the role of the educational psychologist as part of a national educational psychological service which supports students with learning difficulties. The thesis structure was outlined detailing the scope of the constituent parts of the thesis. Finally, an overview is given of the philosophical paradigm and interpretive assumptions which provide the foundations for the current project as well as the reasoning for conducting this exploration at this time.

2. Background and Policy Context

2.1 Overview

The objective of this section is to provide a comprehensive examination of the existing literature pertaining to dynamic assessment in mathematics (MDA). To be alluded to further in the course of this section, dynamic assessment (DA) is a construct which, at its core, emphasises the interaction between the tutor and student in the co-construction of knowledge (Lidz, 1995). It is this interaction between the tutor and student that delineates it from a static, standardised assessment. Despite this defining characteristic DA remains a "fuzzy concept" (Caffrey et al., 2008), and is variable in both research and practice. This variability encompasses several dimensions, one of which is the specific skills that form the central focus of the assessment (Fuchs et al., 2008).

Early practitioners in this area emphasised a need for dynamic assessment to be focused on general problem solving functions as these constructs were considered to be fluid and applicable across multiple domains (Kozulin, 2014; Lidz, 1995). For example, one approach employed in education involves the use of tools that target cognitive constructs thought to underlie performance across a number of domains such as the Children's Analogical Thinking Modifiability Test (Tzuriel & Klein, 1985). The response of the student to mediation in this domain presumably underscores learning potential or propensity across a number of subject areas for diverse groups of learners (Haywood & Tzuriel, 2002).

Therefore, while it is recognized that the focus of DA can vary on a spectrum from very broad, general skills to more specific curriculum-based skills (Jitendra & Kameenui, 1993), there is a recognition that the majority of tasks are of a domain general focus (Grigorenko, 2009). Despite this, curriculum-based measures as a focus for DA in both literacy and numeracy also represents a discernable branch of research in this area (Allsopp et al., 2008; Cho & Compton, 2015; Hasson et al., 2013). The current systematic review aims to summarize the literature that pertains to the use of dynamic assessment procedures focused on mathematics.

This background and policy context section aims to define key concepts within the fields of mathematics education and dynamic assessment to define the review question for the systematic review chapter. This section commences with a structured chronological overview of the progression of numeracy development in infants and children. This is be followed by an examination of mathematics education in the Irish context, including curriculum and teaching methods. Subsequent topics within this review include identifying and assessing mathematics difficulties in Irish schools, as well as the role of school psychological services in supporting students with such challenges, aligned with their service delivery model. This initial section then concludes with an exploration of the theoretical foundations of DA and a summary of the key debates within the literature regarding its analysis and practical application. This will establish the review question for the ensuing systematic literature review.

2.2. Early Numeracy Development

How do human beings begin to understand numerical concepts that later lead to mathematical reasoning in education? Much like nativist theories of language development which implicate innate neurological language learning devices (Chomsky, 1986), much empirical research has led to the identification of an equivalent module in numeracy which has been coined number sense (Dehaene, 2001).

2.2.1. Approximate Number System

Human infants process quantities before they acquire the language to represent them and indeed some theorists suggest that an understanding of quantities is an evolutionarily acquired a-priori principle that underlies learning (Dehaene, 2020; Hauser, 2000). Human infants of six months can discriminate between sets of items that differ by a factor of two in visually displayed sets (Xu et al., 2005; Xu & Spelke, 2000). The factor by which an individual can reliably distinguish between sets of items that are too large to enumerate exactly is referred to as the Weber fraction and research has shown this becomes more refined throughout development (Halberda & Feigenson, 2008; Piazza et al., 2013). The internal system used to represent these quantities is referred to as the approximate number system (ANS) (Dehaene, 2001).

The refinement of the weber fraction over time suggests that sets of items are more accurately and reliably compared when the difference between them is greater. This is the first of two behavioural indicators of the ANS, the second of which contends that when estimating the cardinality of a set there is greater variability with larger sets i.e. it is harder to estimate a set of 100 vs 50 items (Odic & Starr, 2018). The impact of this innate system on future development is shown by longitudinal research that has found a correlation between ANS acuity in pre-school (as estimated by a smaller Weber fraction) and performance in mathematics at six years old (Libertus et al., 2013; Mazzocco et al., 2011). The reliability of this observed relationship is however disputed with some studies suggesting that no relationship is apparent (Sasanguie et al., 2014).

2.2.2. Subitizing and the Object Tracking System

The ANS does not solely account for the development of understanding of numerosities as outlined by findings from empirical studies. For example, at five months, infants can distinguish between a set of eight versus four, but not four versus two items (Wood & Spelke, 2005). Recalling the two behavioural characteristics of the ANS as outlined by Odic & Starr (2018), the two comparisons differ by the same factor and moreover, the latter comparison is representative of smaller numerosities and so should in theory be easier to discriminate.

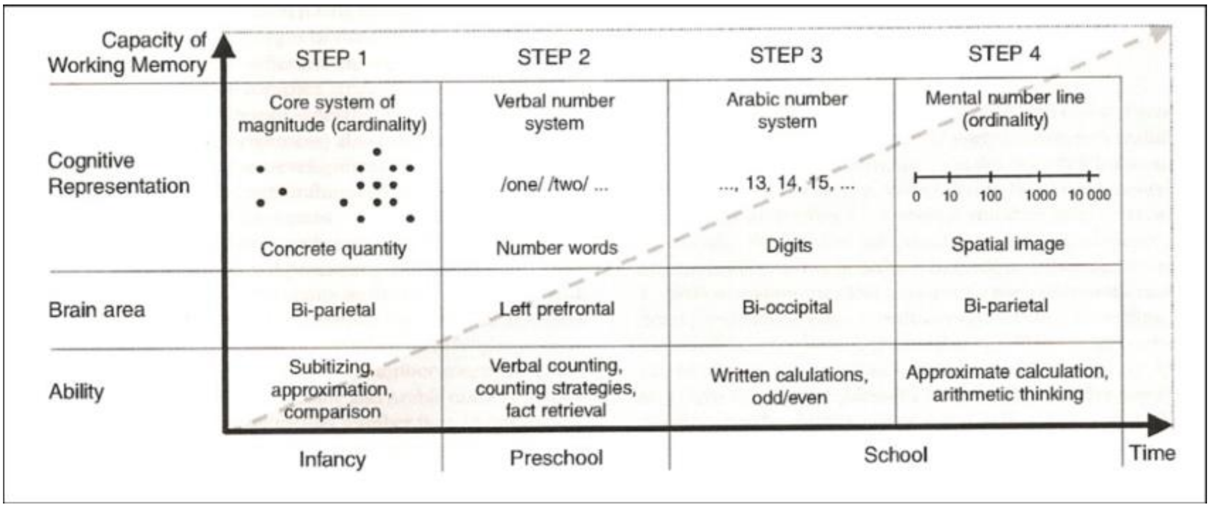
These inconsistencies have led to the suggestion that there are two distinct systems for representation of numerosities in the developing human. The ANS allows for estimation and comparison of quantities in a non-discrete way, but a separate system develops concurrently which allows for enumeration of items exactly and this is referred to as the object tracking system (Piazza, 2010; Pickering et al., 2023). Developmental psychologist Karen Wynne in a series of experiments provides evidence that infants as young as 5 months can mentally represent exact numerosities and even complete basic computation (Hauser, 2000). This precedes and underpins the ability to accurately identify the numerosities of small sets of items which is known as subitizing (Piazza, 2010). The subitizing range typically develops to reach a capacity of about 5 items in school aged children (Benoit et al., 2004; Starkey & Cooper, 1995).

2.2.3. The Influence of Language, Signs and Symbols

Number sense provides a foundation to acquire culturally dependent numeracy and arithmetic skills. The process of this development is presented by von Aster and Shalev (2007), who chronicle this development along four stages as seen at Figure 1. The innate core systems that represent cardinality referred to above (ANS and OTS) precedes the development of a verbal number system through counting. This is followed by a symbolic number system, and finally culminates in the development of a visuo-spatially represented mental number line.

Figure 1

Outline of a Model of Development of Numerical Cognition. Source: von Aster and Shalev (2007)



Note: Figure taken from Von Aster, M. G., & Shalev, R. S. (2007). Number development and developmental dyscalculia. *Developmental medicine & child neurology*, *49*(11), 868-873.

Children learn important properties of number from the development of the verbal number system through counting (Gelman & Meck, 2013). Namely children learn basic concepts that include: numbers always come in the same order; one number represents one set item; set items can be counted in any order; the count of the final set item represents the number of items in the set; and any items in any set can be subjected to counting (Gelman & Meck, 1983). Counting and the learning of these principles represent a discrete stage in the development of numeracy skills.

These discrete numerical values are then encoded with spatial referents. A mental number line is formed which is spatially represented or aligning with the visuo-spatial sketchpad (Baddeley & Hitch, 1974). This construct is supported by documented evidence of a SNARC effect, or spatial numerical association of response codes. The SNARC effect was first demonstrated by seminal researcher and cognitive psychologist Stanislas Dehaene who presented data suggesting, in a forced choice paradigm, smaller numbers are associated with a reduced response time for a left-hand response and larger numbers associated with a reduced response time for right-hand responses (Dehaene et al., 1993). The consistent finding for this effect even through number words suggests numbers are encoded with a spatial property from left to right (Gevers & Lammertyn, 2005; Wood et al., 2008). Moreover, the SNARC effect is reversed for those who read written script from right to left (Dehaene et al., 1993).

The intuitive processing of numerosities and quantities, rehearsal of counting, the relation of these concepts to Arabic number system symbols and the spatial encoding of numbers allows for the development of a visuo-spatial mental number line. The validity of this model comes from evidence that visuo-spatial deficits affect the formation of this mental number line (Bachot et al., 2005; Crollen & Noël, 2015). The visuo-spatial representation of discrete numerical values allows for the flexible and accurate completion of computation (Geary, 2011; Tam et al., 2019). Difficulty with spatially encoding numbers can result in the over reliance on a counting strategy to complete computations which has been shown to be negatively related to later maths achievement (Hopkins et al., 2022).

2.3. Mathematics in Education

Development of numeracy skills is a foundational element of achieving in mathematics, however, this discipline encompasses an array of skills and branches. These branches vary in their content from geometry, with ancient Greek roots stemming from the words “earth” (geo) and “measure” (metron) to more recently coined fields such as algebra established by the mathematician Muhammed ibn Musa Al Khowarizmi in the 9th century

(Rubenstein & Schwartz, 1999). Therefore, the array of skills and content to be covered under maths curricula in schools is extensive.

The breadth of content to be covered presents challenges in defining and refining curricula. Curricula evolve over time based on a number of factors including perspectives on mathematics as a field of study, epistemological views regarding student learning, pedagogical methods, learning materials and assessment (Shimizu & Vithal, 2023). The current overview will examine these factors affecting the development of iterations of maths curricula in Ireland. Another central factor that has shaped educational policy in this regard has been the advent of international assessment and evaluation in mathematics education (Shimizu & Vithal, 2023). The influence of this testing is considered here in the Irish context.

2.3.1. International Evaluation of Ireland's performance in Measures of Mathematics Attainment

Performance of International Students Assessment (PISA) is an assessment of the literacy and numeracy skills of students organised by the Organisation for Economic Co-Operation and Development (OECD). These international assessments began in 2000 and occur in three year intervals (Shiel et al., 2007). PISA mathematics assessments have focused on the concept of mathematisation or flexibility in problem-solving in real world contexts (Shiel et al., 2007). Ireland has consistently achieved average scores for these assessments which is in contrast to literacy performance which is significantly above the OECD average (Close & Shiel, 2009). In 2003, Ireland placed 20th out of 40 participating countries for mathematics (Shiel et al., 2007). 2006 saw Ireland score just above the average for participating countries while in 2009 Ireland dropped below the average mark and ranked 26th out of 34 countries (Shiel et al., 2010).

More recent assessments have seen Ireland's performance improve. The Trends in International Mathematics and Science Studies (TIMSS) is conducted every 4 years offering an evaluation of mathematics performance for children in primary school at 4th class. There was a substantial improvement observed between the cycles of these assessments in 2011 and 2015 which was sustained through 2019 seeing only seven countries scoring significantly higher than Irish students in mathematics in this year and 46 countries scoring significantly lower (Duggan et al., 2023). In 2018 the PISA assessments indicated that 15-year-olds in Ireland scored above average and ranked 21st out of 77 for participating countries in mathematics (O'Reilly et al., 2017). These observable improvements correlate with implementation of policy and curriculum changes introduced in Ireland motivated by prior poor performance.

2.3.2. National Policy to Improve Numeracy levels in Schools in Ireland

A decline in performance in international evaluations circa 2009, particularly in mathematics achievement prompted a media response in Ireland questioning educational policy (Cosgrove & Cartwright, 2014). Initiatives from the government to address these concerns included the development of the project maths curriculum in second level education that closely approximates the PISA assessments that emphasise the importance of real world problem-solving (Kirwan, 2015). On a broader more systemic level, the implementation of The Literacy and Numeracy for Learning and Life, (LNLL) strategy (Department of Education and Skills, 2011), was introduced in response to average scores on international assessments and low levels of problem solving skills in maths (Hislop, 2011).

These national strategies were devised to improve national literacy and numeracy standards by targeting six pillars including teaching, curriculum, assessment and parents and community (Department of Education and Skills, 2011). Relevant strategies across these pillars included a lengthening of the Bachelor of Education degree programme for primary teachers to four years and building a national campaign to build awareness of the role of parents in the development of numeracy skills. The plan was also coordinated with other national policies towards education such as the DEIS initiative (*DEIS Delivering Equality of Opportunity In Schools*, 2020). Analysis of TIMSS results suggests the implementation of the LNLL strategy correlates with a decrease in variance in mathematics scores between advantaged and disadvantaged schools (Karakolidis et al., 2021).

A review of the LNLL strategy conducted in 2017 documented attainments of criterion referenced targets such as an increase in primary school students attaining at or above level 3 for mathematics to above 40% and a reduction of those attaining at or below level 1 to below 30%. Critically however, the interim review acknowledged the need for a greater focus on numeracy goals (Department of Education and Skills, 2017). Relevant stakeholders have now been consulted with regard to the production of a new literacy, numeracy and digital literacy strategy to specify new measurable targets (Kennedy et al., 2023).

2.3.3. Mathematics Curriculum.

The LNLL strategy detailed the importance of a review of the project maths curriculum at post-primary level and an increase of 70 minutes per week in the amount of time spent developing numeracy skills at primary level (Department of Education, 2017). The primary mathematics curriculum in Ireland (Government of Ireland, 1999) has also been subject to intense evaluation in the past decade which has culminated in the introduction of the new primary maths curriculum in 2023, (NCCA, 2023).

How curricula are designed varies by geographical location and is affected by epistemological views of how students should obtain an understanding of relevant concepts (Shimizu & Vithal, 2023). An important distinction here is between empiricist, structuralist and mechanist views. An empiricist perspective suggests students should use mathematical thinking to relate to the perceived world. The structuralist view suggests that students should aim to understand mathematical structures without reference to the real world. Finally, a mechanist view perceives mathematics as a body of knowledge to be acquired and emphasizes the learning of mathematical rules and formula (O'Reilly et al., 2017). While the advent of project maths at post-primary level saw a move in the intended curriculum towards an empiricist epistemological stance, a balanced curriculum necessarily maintains some aspects of abstract conceptualisation consistent with a structuralist view (Kirwan, 2015).

These views are inherently linked to pedagogical approaches. A constructivist approach to pedagogy places an emphasis on the role of the teacher as a facilitator of knowledge acquisition and is congruent with an empiricist epistemological view, which has been advocated within the curricula in Ireland for years (O’Shea & Leavy, 2013). The advent of the new primary maths curriculum (NCCA, 2023) advocates for the consideration of socio-cultural, cognitive and constructionist pedagogical perspectives with a clear emphasis on mathematical talking, thinking and playing (Dooley, 2019).

2.3.4. Primary Maths Curriculum in Ireland (GOI, 1999)

The primary school mathematics curriculum implemented in Ireland in recent years was published in 1999 (Government of Ireland, 1999). The curriculum detailed the common strands to be covered including shape and space, data, number, measures and algebra (Government of Ireland, 1999). This curriculum was outlined as a guidebook for not only what children were to learn but how they were to learn it, with an emphasis placed on children’s own experiences in acquiring knowledge and skills through working with materials individually and in small groups (Dunphy, 2009).

The curriculum, during its tenure was subject to extensive evaluation, particularly in the aftermath of results of international evaluations as previously alluded to, which formed the basis for the development of a new curriculum. The NCCA published research reports number 17 (Dunphy et al., 2014) and 18 (Dooley et al., 2014), that outline the theoretical underpinnings and teaching and learning concepts important in early childhood mathematics education respectively (NCCA, 2022). These reports emphasise the importance of a move away from mechanist views of curriculum content and a move towards mathematisation, emphasising the importance of mathematical discourse, communication, reasoning and problem solving (Dooley et al., 2014; Dunphy et al., 2014).

In a more general sense, the aim of early mathematical education is to promote mathematical proficiency (Dunphy et al., 2014), which is identified as comprising of:

1. Conceptual understanding
2. Procedural fluency
3. Strategic competence
4. Adaptive reasoning
5. Productive disposition

2.3.5. New Primary Maths Curriculum in Ireland (NCCA, 2023).

The new primary maths curriculum was developed by the National Council for Curriculum and Assessment and published by the Department of Education (NCCA, 2023). Primary schools will introduce the new curriculum in the 2024/2025 academic year and are currently receiving support for implementation from the National Council for Special Education and the support service for teachers - Oide. The curriculum incorporates the same strands as the previous iteration and is accompanied by progression continua which outline the stages of development of proficiency under four identified core elements. These core elements are informed by the components of mathematical proficiency identified in the NCCA report number 17 (Dunphy et al., 2014). These elements are:

1. Understanding and connecting,
2. Communicating,
3. Reasoning and applying,
4. Problem-solving

The curriculum presents seven key competencies that are targeted for development. All of these competencies include the term “being” which suggests the goal of the learning experiences at primary school level is to facilitate the ability and the willingness of the learner to think mathematically as opposed to reaching a level of skill or knowledge acquisition (NCCA, 2023). For example, the competencies “being mathematical”, “being creative” and “being an active learner” emphasise the active role of the learner in their education. The curriculum endorses the recommendations for good mathematics teaching made in NCCA report 18 and the following addendum related to fostering these competencies by promoting playfulness and providing appropriate scaffolding (Dooley, 2019; Dooley et al., 2014). Moreover, a greater emphasis is placed on the development of meta-cognitive skills such as reflection and monitoring which promotes more autonomous learners in mathematics (Dooley, 2019; Dooley et al., 2014). This is reflected under the competency of being an active learner in the new curriculum (NCCA, 2023). This emphasis on executive functioning aligns the goals of the new curriculum with the principles of dynamic assessment to be discussed later in this chapter.

2.3.6. Identification of Maths Difficulties

A further consideration in the relationship between assessment and mathematics education is the current protocol for identification of maths difficulties and how dynamic assessment may be employed within this system. Maths difficulties can arise at any stage of schooling and can vary in the degree of pervasiveness and severity (Gersten, Jordan, et al., 2005). In Ireland, the continuum of support has been implemented in schools since the enactment of the Education of Persons with Special Educational Needs Act (EPSEN) (2004). Guidelines for the use of a tiered system to identify and respond to needs of pupils were subsequently published to support schools to support their learners (NEPS, 2007). The system consists of three tiers of response namely *Support for all, Support for some*, and *Support for few*. The tiered system outlines protocols for addressing additional educational needs in collaboration with parents by differentiating material, administering interventions, setting targets, and tracking progress. At the third tier of support there is an assumption that the school have implemented appropriate interventions to address the identified concerns and collaboration with external agencies may be required (NEPS, 2007).

Identifying educational needs is the primary responsibility of the class teacher (NEPS, 2007). One important way that teachers identify educational needs is through standardised assessments. According to circular 0056/2011 schools are obligated to administer standardised assessments in literacy and numeracy for children at the end of 2^{nd}, 4^{th} and 6^{th} class as part of the aforementioned national literacy and numeracy strategy (Department of Education and Skills, 2011). Learning support guidelines suggest that those scoring below the 10^{th} percentile in standardised assessments should be prioritised for access to additional support within the school (Department of Education and Science, 2000).

Identification of those in need of support at a higher level of the continuum can also be informed by observation and monitoring of classwork or formative assessment. Formative assessment is referred to as “assessment for learning” and used to inform teaching. The

NCCA (2008) published assessment guidelines for schools and outlined protocols for conducting formative assessment. The guidelines highlight the fact that assessment in the primary school context should be used to discern not only *what* the child learns but *how* the child learns. The teacher can therefore identify the short-term and long-term needs of the student by conducting formative assessment through everyday interactions with the student. Moreover, a less cluttered new primary mathematics curriculum gives more autonomy to teachers to conduct such an assessment process within the classroom setting (NCCA, 2016, 2023). The process of modifying assessment parameters to determine the processes used by the child to complete tasks and inform how best to support the child going forward is a common principle of both formative assessment and dynamic assessment (Haywood, 2012; NCCA, 2008)

2.3.7. The Role of the Educational Psychologist in Supporting Pupils with Maths Difficulties in Schools in Ireland

The role of the educational psychologist (EP) in supporting pupils with maths difficulties is multi-faceted. On a national level, EPs as part of the NEPS produced a comprehensive set of guidelines for teachers to support assessment and intervention in the domain of mathematics (NEPS, 2020). The guide refers to concepts already discussed such as development of number sense as well as constructs such as executive functions, working memory and maths anxiety. The document also lists a number of relevant structured programmes to address mathematics difficulties at the level of “support for some” on the continuum of support (NEPS, 2007). This is consistent with the NEPS’ model of service delivery which is based on a consultative model and prevention science (National Educational Psychological Service, 2020).

Moreover, EPs in the NEPS can also conduct individual assessments as part of direct casework at the third tier of the continuum of support for pupils considered to have enduring difficulties in maths despite access to appropriate intervention. The query for such assessments is often whether the pupil is presenting with a specific learning difficulty in mathematics. The nomenclature for such deficits is varied and includes names such as mathematics learning disability/disorder, maths learning difficulties, dyscalculia, developmental dyscalculia etc. (Kaufmann & von Aster, 2012). EP's involvement in direct casework with pupils with this presentation is significantly less frequent when compared with the same isolated difficulties in literacy. This is despite prevalence rates for dyscalculia reported to be between 3 and 7% informed by the previous Diagnostic and Statistical Manual of Mental Disorders 4th edition (DSM-IV) diagnostic criteria (Reigosa-Crespo et al., 2012; Shalev et al., 2000; Shalev & Von Aster, 2008) and 5.7% under the updated criteria in the 5th edition of the DSM (Morsanyi et al., 2018).

EPs may be less frequently involved in direct casework of this kind due to the lack of opportunity to link assessment to intervention in this domain. Comparatively, in the literacy domain those that are determined to have significant enduring difficulties in reading, writing or spelling may qualify for a grant for assistive technology with the supplementation of a psychological report (Department of Education and Skills, 2013). Although not the remit of the EP, assessments to determine literacy proficiency at post-primary level are conducted to inform applications for reasonable accommodations for certificate examinations (RACE). The equivalent of these supports is not available in the numeracy domain. With an emphasis placed on goal directed assessment processes by commonly used formulation models in educational psychology practice such as the assessment for intervention model (Pameijer, 2016), it is logical to expect less assessment work related to mathematics difficulties in schools. However, dynamic assessment is more commonly being used as an approach to direct casework by EPs to reduce the gap between assessment and intervention (Deutsch &

Reynolds, 2000; Hill, 2015). The following sections overview dynamic assessment and the potential applications to pupils experiencing mathematics difficulties.

2.4. Dynamic Assessment

Dynamic assessment is an umbrella term used to describe a mode of assessment where the main identifying characteristic is the interactive nature and active role of the administrator in the assessment process (Lidz, 1995). In contrast to a static standardised assessment used in educational settings to quantify achievement at an individual level, the dynamic assessment cannot provide such a metric as the outcome score is a product of the input of both the examiner and examinee (Haywood & Lidz, 2007). The query then arises as to what can be discerned from such an approach if not what the learner is capable of independently? The answer to which proposed by Vygotsky (1978, as cited by Lauchlan & Daly, 2023), is that in many ways you can learn more about a child’s cognitive development from what they can do with others than what they can achieve independently. Haywood and Tzuriel, (2002) add to this stance by suggesting that learning and test conditions contribute to every individual learning at less than 100% of their potential. Thus, the aim of testing should be to determine what conditions are conducive to learning and performance (Haywood, 2012).

This broad encapsulation of the idea of dynamic assessment has led to ambiguity regarding its definition and examination within scholarly works. Caffrey et al., (2008) acknowledges dynamic assessment as a “fuzzy construct”, one where clarity is often not provided regarding theory, purpose, and procedure. Relevant variance and agreement within the literature pertaining to this approach under these headings are discussed in the following paragraphs.

2.4.1. Background and Theoretical Underpinnings

It is commonly recognised that dynamic assessment owes its theoretical roots to socio-cultural theory and the concept of the zone of proximal development (Vygotsky & Cole, 1978; Elliott, 2000, Lidz, 1995; Lauchlan & Daly, 2023). While human beings are far from unique as an organism in being born with a propensity to learn, (i.e. interact with the environment and modify behaviour or internal processes as a result) human beings are unique in the quality of cultural transmission of learning (Dehaene, 2020). Socio-cultural theory recognises how human beings are adaptable according to the transmission of psychological tools from one generation to the next which is not necessarily accounted for in biological or genetic terms (Bodrova & Leong, 2007).

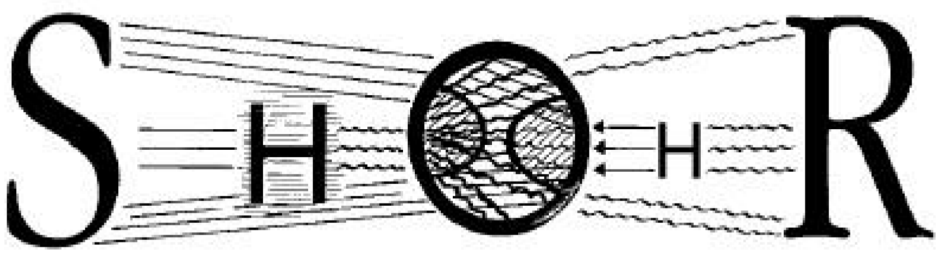
Vygotsky proposed that learning happens in the social plane first and is then internalised as thought (Bodrova & Leong, 2007). It is within this social interaction that development occurs, and this primarily takes place in the presence of a more capable other. The interaction with the more capable other is not only significant but essential as it allows for the development of skills of which the individual is not yet capable on their own (James, 2010). Vygotsky called this concept the zone of proximal development (ZoPD) (Moll, 1990) and stressed that learning is not always dependent on development but development may in fact, result from learning (Bodrova & Leong, 2007).

The shaping of dynamic assessment into a practical approach applied in clinical and educational settings is often attributed to Reuven Feuerstein, who worked in the early 1950's with war-displaced Jewish children (Haywood, 2012). Feuerstein observed that static standardised assessment of these children's cognitive abilities indicated they were performing significantly below the level of their peers. However, by altering administration and providing scaffolding, the children's scores improved substantially (Falik, 2019; Haywood, 2008). Consistent with Vygotsky's teachings, this led Feuerstein to believe that the deficit originally observed in the standardised testing of the children was attributable not to a biological or genetic determinant but a social/cultural one, namely the lack of exposure to mediation of environmental stimuli by more capable others (Falik, 2019).

An acknowledgement of the importance of mediation led Feuerstein to coin the term "Mediated Learning Experience" (MLE) (Feuerstein et al., 1991), to denote a special quality of interaction where the mediator interposes themselves between the learner and the task to modify the stimuli for them (Tzuriel, 2013). This is referred to as a tripartite relationship and distinguishes clearly from behavioural and constructivist models of epistemology by identifying the crucial role of the mediator in the acquisition of knowledge. Figure 2 visually illustrates the position of the mediator between the stimulus and organism on the left, and again between the organism and the response on the right. The theories of the ZoPD and SCM therefore outline clearly the importance of determining what a learner can achieve with the help of a more capable other and how cognitive development can be fostered through this interaction consistent with the aims of dynamic assessment (Lidz, 1995).

Figure 2

Visual Depiction of the Mediation of Environmental Stimuli



2.4.2. Purpose of Dynamic Assessment

A prominent argument with regard to the purpose of dynamic assessment is whether itshould be used to quantify learning constructs and statistically compare groups or whether it should be used to gain an in-depth understanding of the individual (Caffrey et al., 2008; Daneshfar & Moharami, 2018; Fuchs et al., 2008; Lidz, 1991). This argument is prominent within psychology in general as a discipline with the disparate ideologies referred to as nomothetic and idiographic approaches (Hermans, 1988). Nomothetic approaches stress the importance of general principles or common measurable and comparable constructs across a sample or population. Empirically, such an approach is consistent with experimental and correlational research designs and quantitative statistical analysis. An idiographic approach conversely gives prominence to the variation within the individual and suggests an in-depth exploration of idiosyncrasies is more meaningful than inter-individual commonalities (Haywood, 2012). Such an approach is consistent with case study design and qualitative analysis.

Quantitative analysis of dynamic assessment consistent with the nomothetic approach is divisible further and this is owing largely to how authors view its purpose. Caffrey et al., (2008) make an important delineation between clinically oriented versus research oriented dynamic assessment. This distinction lies in the identifiable separate branches of research that examine how dynamic assessment can provide an approach to addressing cognitive and motivational deficits within a sample (i.e., clinical application) and how it can be used to identify and measure a learning potential construct (i.e. research application).

These two separate branches are clearly identifiable within the literature because of the design and statistical analyses employed within the respective categories. Studies that fall within the clinically oriented category typically employ a comparative design and use statistical methods such as t-tests or mixed factorial ANOVAs to identify differences between pre and post-training test scores, (Daneshfar & Moharami, 2018). Conversely in the research-oriented branch the aim is to measure the learning potential construct, which is achieved by measuring an individual's performance with mediation by a more capable other. By subtracting what the individual can do without mediation, this gives a measure of the zone of proximal development as previously alluded to. This construct may have utility in predicting performance at a later time point (e.g. Fuchs et al., 2008).

Learning potential measures have been used within the literature to distinguish between those who would and would not benefit from mediation. For example Kirkwood et al., (2001) utilised a DA of the Rey Ostereith Complex Figure Test by structuring the administration to aid encoding and found one cohort of children's performance improved while the other did not. The cohort that did not improve scored poorly on a measure of visual processing. The utility of DA in identifying subgroups based on response to accommodations has been documented in a number of areas particularly discriminating language and learning difficulties (Barrera, 2006; Hasson et al., 2013). In this vein, dynamic assessment has been closely aligned with a response to intervention paradigm to identify homogenous subgroups of low performers as outlined by Grigorenko, (2009).

2.4.3. Procedure and Methodology.

Dynamic assessment is usually implemented in either a sandwich or a cake format (Daneshfar & Moharami, 2018). A sandwich format consists of an initial independent pre-test, a training or mediation phase and finally an independent post-test. By implementing this method, researchers and clinicians can measure the change from pre-test to post-test and quantify improvement. Conversely the cake method of interaction consists of the continuous layering or altering of mediational practices and analysis of the effects of said mediation on performance. In contrast to the sandwich method, mediation is offered on an item by item basis often in the form of a list of pre-determined prompts (Behrooznia, 2014). Both sandwich and cake formats are commonly used in a nomothetic research design but have potential for implementation in a more individualised fashion.

A final distinction to be made is that between interventionist and interactionist dynamic assessment. Proponents of interventionist approaches emphasise the need to strive for standardised administration and reliable measurement of outputs (Daneshfar & Moharami, 2018). One method of achieving this is the graduated prompts approach (Campione & Brown, 1987) which utilises a pre-determined list of hierarchically organised prompts to support the individual to achieve mastery of the task. By utilising this method performance can be quantified as either the level of mastery achieved, or the explicitness of prompts needed to achieve mastery (Fuchs et al., 2008).

Conversely, alternative approaches emphasise the importance of the interaction between the tutor and pupil which is more reactionary to the unfolding learning process (Daneshfar & Moharami, 2018). Interactionist methodologies are process-focused rather than outcomes focused and strive to gain a more in-depth understanding of the pupil. Interactionist approaches provide an output which is a comment on both the mediator's skills and the individual's receptiveness to mediation. By interacting fluidly with the individual and altering the assessment parameters the role of the mediator can be seen to at least consist of the following:

1) To identify barriers to learning.
2) To gain a more complete understanding of the unique processes employed by the individual to complete the task.

3) To identify cognitive/affective constructs which are developing and require scaffolding.
4) To identify appropriate and effective scaffolding approaches to support learning and development.

2.4.5. Overview of Key Arguments Pertaining to Dynamic Assessment.

An overview of the opposing perspectives on the essence of dynamic assessment under the headings listed above suggests that these loosely align with two separate theoretical stances as portrayed in Table 1

Table 1

An outline of how opposing views in relevant domains loosely align to two different theoretical stances on the essence of dynamic assessment. Source: author

	Position 1	**Position 2**
Approach to study design	Nomothetic	Idiographic
Nature of interaction	Interventionist	Interactionist
Aims	Research oriented v clinically oriented	Process focused
Data Analysis	Quantitative	Qualitative

2.4.5.1. Criticism of the idiographic approach. While a more individualised approach to dynamic assessment yields richer data and a more comprehensive picture of the learner's profile, the approach is not without criticism. Namely the inter-rater reliability between professionals is not adequate and it is proposed it is difficult to discern where the input of the examiner ends and where the unique contribution of the examinee begins (Lantolf & Poehner, 2004; Lidz, 1995). With increasingly individualised approaches there is also a trade-off between examiner expertise and richness of data obtained i.e., standardised pre-determined lists of prompts are easy to administer yet do not yield as rich data, while individualised approaches yield rich data but require extensive expertise in administration. This trade-off is key to practice in schools as concerns related to interpretation and implementation of dynamic assessment approaches are documented from teachers and EPs alike (Bosma & Resing, 2010; Elliott, 2000).

2.4.5.2. Criticism of the nomothetic approach. Seminal authors in this area suggest that while the administration of set graduated prompts is a more reliable approach to dynamic assessment it is against the essence of dynamic assessment in accordance with its theoretical underpinnings (Haywood, 2012). It is suggested in relation to dynamic assessment:

"The critical principle is that there is no divide between assessment and intervention. Intervention is assessment, and assessment is the intervention. The clinician learns about the client by testing the client's skill, knowledge, and ability to learn…. The interaction is simultaneously an assessment of the client's current level of functioning and an intervention to boost that level." (Haywood & Lidz, 2007, p. xiii.).

This critical principle aligns with the philosophy outset at the beginning of this section acclaiming that it is more valuable to discern what an individual can achieve with support than what they can achieve on their own (Lauchlan & Daly, 2023). Advocates of the nomothetic approach deny the validity of this principle. Conversely, criticism of the nomothetic approach would suggest that measuring an individual's performance post mediation and comparing it to a pre-training score is in essence a variation of a static form of assessment (Haywood, 2012; Lidz, 1995)

2.5. Mathematics and Dynamic Assessment Review Question.

Dynamic assessment as alluded to above is an umbrella term for an approach to assessment and does not encompass a specific range of tools. Lauchlan and Daly (2023) note that the focus of the dynamic assessment is one of three key constituent parts (the other two parts are referred to in section 4.2.1 in the next chapter). Indeed, the focus of a dynamic assessment can be any subject matter and is of great significance (Fuchs et al., 2008). While early approaches to dynamic assessment emphasised the importance of using general tasks to target general problem-solving cognitive functions, a discernable separate branch within the field recognises that SCM applies to curriculum based tasks and domain specific cognitive learning functions also (Kozulin, 2014).

There are a number of reasons why mathematics as a domain specific subject area may be well aligned with dynamic assessment particularly within the Irish context. These reasons primarily concern the identified shift in the mathematics curriculum away from mechanist views of subject matter towards an emphasis on the development of mathematisation and autonomous mathematical thinkers (National Council for Curriculum and Assessment, 2023). Furthermore, there is a lack of clarity related to the role of the EP in supporting children with maths difficulties through direct casework. Dynamic assessment as an approach aims to reduce the gap between assessment and intervention and aims to uncover the processes used by the child for task completion as well as potential effective methods to support the child's learning (Feuerstein et al., 1991; Tzuriel, 1992). For these reasons, the scope of the current review will be to explore what is already known about the implementation of dynamic assessment procedures in relation to mathematics in primary schools.

3. Systematic Literature Review

3.1 Overview

The following chapter details the procedure and methodology of a systematic review of the literature in the area of mathematics focused dynamic assessment (MDA) in educational settings. The choice of this review topic is informed by personal interest and professional experience on the part of the researcher with teachers in educational settings indicating numeracy is an area where teachers require further support and resources.

Dynamic assessment is an umbrella term that incorporates variability in relation to the aims, procedure and focus of the assessment (Caffrey et al., 2008; Fuchs et al., 2008). One defining characteristic of a dynamic assessment however is the dynamic interchange between the examiner and examinee which distinguishes this approach from static assessments (Haywood & Lidz, 2007; Lidz, 1995). Theoretical frameworks that underpin dynamic assessment include the zone of proximal development (ZoPD) (Vygotsky & Cole, 1978) and structural cognitive modifiability (SCM) (Feuerstein et al., 1991). The ZoPD aligns with dynamic assessment in the recognition of the role of the more capable other in the social construction of knowledge and the acquisition of culturally relevant psychological tools through social interaction (Bodrova & Leong, 2007). The theory of SCM provides a theoretical foundation for dynamic assessment in the recognition of the need for a mediator to interpose themselves between a learner and a stimulus to promote learning (Feuerstein et al., 1991). SCM suggests that cognitive structures can be modified and in particular the implementation of a specified type of reciprocal interaction coined a “mediated learning experience” enhances the likelihood of modifiability (Feuerstein et al., 2002; Tzuriel, 2013).

While dynamic assessment is often focused on broad domain general psychological constructs such as analogical and inferential reasoning (Lidz, 1995; Tzuriel & Klein, 1985), curriculum-based dynamic assessment is more frequently being examined within the literature with relevance to education (Elliott, 2003; Elliott, 2000; Kozulin, 2014). The exploration of the use of dynamic assessment focused on mathematics tasks may be relevant particularly within the Irish context as a recent curriculum revision has seen a need recognised to promote mathematical thinking and communication through playfulness and collaborative exchanges (NCCA, 2023). This new curriculum also gives teachers more autonomy to assess learning through interaction consistent with guidelines for assessment for learning (NCCA, 2008). These are principles consistent with the theoretical underpinnings of dynamic assessment.

3.2. Systematic Review Procedure

A systematic review therefore was undertaken to determine what has been explored in the literature in the area of mathematics and dynamic assessment. Using a systematic approach to reviewing literature which details a review question, search strategy and inclusion criteria prior to conducting a search is a hallmark of good quality research for a number of reasons. This approach ensures a thorough and broad search strategy reducing the chances of missing key sources of evidence but also reducing the chances of bias in reporting identified evidence (Booth et al., 2021). The systematic review follows the stages set out below adapted from those outlined by the Joanne-Briggs Institute (*Introduction to JBI Systematic Reviews*, n.d.).

1. Formulating a review question
2. Defining inclusion and exclusion criteria
3. Locating studies through searching
4. Selecting studies for inclusion

5. Assessing the quality of studies
6. Extracting data
7. Analysing and synthesising the relevant studies

3.2.1 Formulating a Review Question

The formulation of the review questions was informed by a review of the theoretical underpinnings and relevant literature in relation to dynamic assessment as outlined in the background and policy context chapter (chapter 2). Owing to the broad nature of what could be conceived to be incorporated under the term dynamic assessment and the diverse designs and methods used in its analysis in published literature, the review question of the current chapter was constructed to be purposely broad. This allows for the inclusion of published work that is varied in terms of methodology, design and data analysis which will all be categorised in the synthesis of the review.

The scope of the current review however will be refined to studies that implicated MDA procedures which is necessary to define. Dynamic assessment exhibits variability in terms of the tasks employed and the skills or constructs being analysed (Elliott, 2000). Early advocates of this approach stressed the effectiveness of using general tasks to evoke domain general cognitive constructs (Lidz, 1995). Conversely, the scope of the current review will be reduced to analysis of studies that utilise dynamic assessment procedures that employ a mathematics specific task which may be curriculum based or more generic as its primary focus. Henceforth such a process is termed mathematics dynamic assessment (MDA). The current research question therefore is:

"What has been found by employing a mathematics dynamic assessment in empirical research in the primary school population?"

3.2.2 Defining Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were determined by the review question and what constitutes MDA. Defining what constitutes dynamic assessment in some cases is subjective as there is no discrete definition regarding its boundaries. Defining characteristics of the approach that relate to an interaction between an individual and more knowledgeable other to discern learning potential (Haywood & Lidz, 2007; Lidz, 1995) is sufficiently sensitive but not specific. For example, studies that assess the quality of interventions often implement a pre-test, train, post-test design as part of a single sample or repeated measures design (Sullivan, 2008). Studies that purport to implement dynamic assessment, that utilise a sandwich design in quantifying the gains made by a subject following mediation (Daneshfar & Moharami, 2018) may be indistinguishable from repeated measures experiments.

Such study designs will be deemed to be included in the current analysis if they are referred to as a dynamic assessment by the authors. Notably the weighting of this evidence in the final synthesis will be adjusted with reference to criteria detailed by seminal author Carl Haywood (2012). These criteria to be elaborated on in further detail in subsequent sections are threefold and include the necessity for the assessment or interaction to be idiographic, process focused and highlight educability. Table 2 below outlines the inclusion and exclusion criteria for the purpose of the current review along with the justification for the relevant criteria listed.

Table 2

Inclusion and exclusion criteria and rationale for the current review articles

Criteria	Inclusion	Exclusion	Rationale
Peer reviewed	Academic research published in a peer-reviewed journal	Material published that has not been peer reviewed – including books, blogs, online articles, opinion pieces etc.	The aim of the review was to identify studies that are deemed relevant and of an appropriate standard as adjudged by researchers in this area that examine the use of DA in maths in primary school children.
Primary empirical research	Primary empirical research. The published work must be the subject of primary data collection and analysis.	Secondary research including reviews. Narrative or opinion pieces that are not the subject of systematic data collection or analysis.	The scope of the review is to collate primary empirical evidence which can all be appraised according to the same evaluative frameworks which allows conclusions to be drawn based on research conducted in accordance with the scientific method.
Participants	Children or young people in primary school or pre-school (ages 3-13), If the study includes participants within the age and outside the age range (e.g.,12-15) then the study was deemed to be included.	Participants in post primary school or older (14 and older)	The scope of the current review is limited to primary school aged children. The majority of assessment work is done at this stage of schooling.
Subject of the research	The focus of the research must be on maths dynamic assessment. MDA can be administered in the cake or sandwich design. To differentiate MDA from a generic maths intervention the article must allude to dynamic assessment or make reference to learning potential or the Zone of proximal development. Furthermore, the training phase may reference mediated learning experiences.	Studies will be excluded if the focus is a static maths task that is not administered in a dynamic way. Generic maths interventions with a pre-test, intervention, post-test design.	The subject of the review is of maths dynamic assessment based on the theoretical framework of socio-cultural theory and the zone of proximal development. The review therefore must distinguish between research designs that explore learning potential through social constructivism and generic interventions which improve maths achievement.

Design of the research	Quantitative data collected as a result of this administration must define MDA as an independent variable in experimental research (when MDA is considered an intervention). It may also be an outcome variable to compare learning potential in maths across groups in cross sectional research. It may also be a predictor variable to account for variance in achievement in maths (when the predictive validity of MDA is being assessed).	Dynamic assessment of a domain general task that is not related to maths such as language skills regardless of whether it is used as a predictor of later maths skills or not. If a study employs MDA to measure learning potential as a dependent variable as a function of an intervention implemented in an experimental design.	The aim of the review is to answer the question of what can be discerned from employment of maths dynamic assessment procedures. This excludes the analysis of general dynamic assessment or the analysis of learning potential as a dependent variable to test the effectiveness of an intervention programme.
Language	Studies that are in English	Studies that are not in English or translatable to English	Will allow author to read the study

3.2.3 Locating Studies through Searching

Five databases were used to search for studies that employed MDA procedures in primary school samples. The five databases selected were ERIC, Web of Science, PsycArticles, PsycINFO and Scopus. These databases were selected to optimise the focus and scope of the search. For example, databases PsycArticles and PsycINFO have disciplinary focus related to psychology, while ERIC encompasses research that has relevance in the educational domain. The databases Web of Science and Scopus enhance the scope of the search as they are broad cross-disciplinary databases.

The search terms were comparable across databases and were informed by consultation of the literature in this area. As such, dynamic assessment is referred to by a number of terms such as “learning potential assessment” and “interactive assessment” amongst others. The search terms and databases used for the purpose of the current review as well as number of results identified are outlined below at Table 3.

Table 3

Table showing search terms, databases used, and results obtained for original search.

Database	Search terms	Filter applied	Number of results
ERIC	(abstract("Dynamic assessment") OR abstract("Learning potential assessment") OR abstract("cognitive abilities profile") OR abstract ("cognitive modifiability") OR abstract("interactive assessment") OR abstract("dynamic testing") OR abstract("mediated learning experience")) AND (abstract(math*) OR abstract(numeracy) OR abstract(arithmetic) OR abstract(calculation) OR abstract("problem solving"))	English Peer-reviewed	94
Web of Science	(AB=("dynamic assessment") OR AB=("learning potential assessment") OR AB=("cognitive abilities profile") OR AB=("cognitive modifiability") OR AB=("mediated learning experience") OR AB=("interactive assessment") OR AB=("dynamic testing")) AND (AB=(math*) OR AB=(arithmetic) OR AB =(numeracy) OR AB=("problem solving") OR AB=(calculation))	Limited to Articles English Including Education educational research, psychology educational, education special, mathematics interdisciplinary applications, multidisciplinary sciences, psychology multi-disciplinary, psychology experimental, education scientific disciplines, psychology developmental, mathematics, mathematics applied, psychology applied, psychology clinical,	79
PsycINFO	(AB "dynamic assessment" OR AB "learning potential assessment" OR AB "cognitive abilities profile" OR AB "cognitive modifiability" OR AB "mediated learning experience" OR AB "interactive assessment" OR AB "dynamic testing") AND (AB math* OR AB numeracy OR AB arithmetic OR AB calculation OR AB "problem solving")	English Academic journals	90
Scopus	(ABS ("dynamic assessment") OR ABS ("learning potential assessment") OR ABS ("cognitive abilities profile") OR ABS ("cognitive modifiability") OR ABS ("interactive assessment") OR ABS ("dynamic testing) OR ABS ("mediated learning experience")) AND (ABS (Math*) OR ABS (calculation) OR ABS (arithmetic) OR ABS ("problem solving") OR ABS (numeracy))	Article English Social sciences, psychology, maths	98
PsycAricle	(AB "dynamic assessment" OR AB "learning potential assessment" OR AB "cognitive abilities profile" OR AB "cognitive modifiability" OR AB "interactive assessment" OR AB "dynamic testing OR AB "mediated learning experience") AND (AB Math* OR AB calculation OR AB arithmetic OR AB "problem solving" OR AB numeracy)		4

3.2.4 Selecting Studies for Inclusion

Using the search terms across the relevant databases as outlined above, identified 365 studies. These studies were imported into Zotero referencing software. Using this software all duplicate studies were removed leaving 181 unique studies. These studies' abstracts were then screened using the inclusion/exclusion criteria outlined in Table 2. Following this process a further 130 studies were excluded and 51 remained. These studies were then screened against the inclusion/exclusion criteria again based on the contents of the full article. 37 further studies were excluded. All excluded studies and reasons for exclusion in accordance with the criteria set out in Table 2 are listed at Appendix 1. The remaining 14 studies which are the focus of the review are listed at Table 4. A prisma flow diagram which outlines screening processes is displayed at Figure 3.

Table 4

List of included studies following screening processes

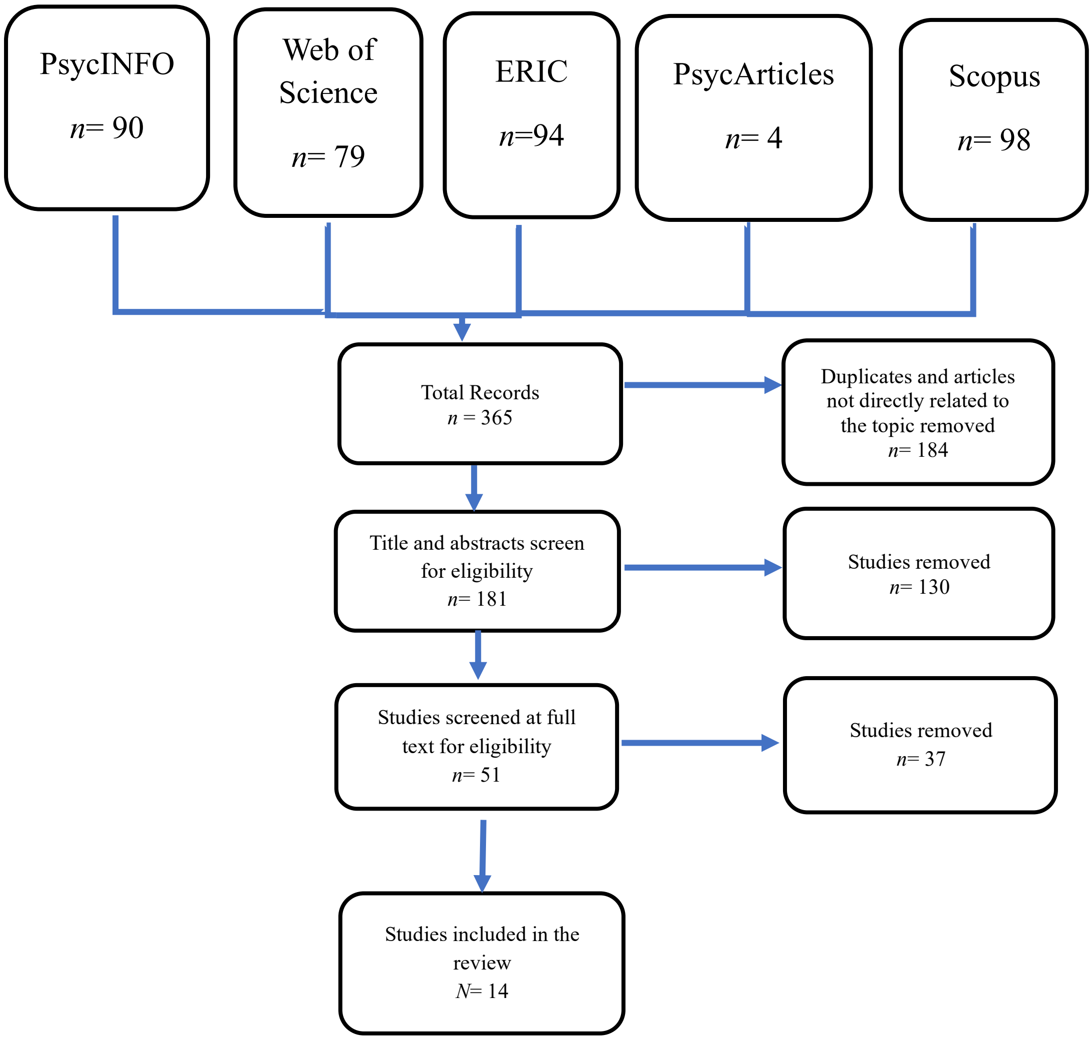
Included Studies
Al-Hroub, A. (2021). Utility of psychometric and dynamic assessments for identifying cognitive characteristics of twice-exceptional students. *Frontiers in Psychology*, *12*. APA PsycInfo. https://doi.org/10.3389/fpsyg.2021.747872
Al-Hroub, A., & Whitebread, D. (2019). Dynamic assessment for identification of twice-exceptional learners exhibiting mathematical giftedness and specific learning disabilities. *Roeper Review: A Journal on Gifted Education*, *41*(2), 129–142. APA PsycInfo. https://doi.org/10.1080/02783193.2019.1585396
Brownell, M. T., Mellard, D. F., & Deshler, D. D. (1993). Differences in the Learning and Transfer Performance between Students with Learning Disabilities and other Low-Achieving Students on Problem-Solving Tasks. *Learning Disability Quarterly*, *16*(2), 138–156. Education Collection. https://doi.org/10.2307/1511136
Bosma, T., Stevenson, C. E., & Resing, W. C. M. (2017). Differences in Need for Instruction: Dynamic Testing in Children with Arithmetic Difficulties. *Journal of Education and Training Studies*, *5*(6), 132–145. Education Collection; ERIC.
Cho, E., Fuchs, L. S., Seethaler, P. M., Fuchs, D., & Compton, D. L. (2020). Dynamic Assessment for Identifying Spanish-Speaking English Learners' Risk for Mathematics Disabilities: Does Language of Administration Matter? *Journal of Learning Disabilities*, *53*(5), 380–398. Scopus. https://doi.org/10.1177/0022219419898887
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Craddock, C. F., & Hamlett, C. L. (2008). Dynamic assessment of algebraic learning in predicting third graders' development of mathematical problem solving. *Journal of Educational Psychology*, *100*(4), 829–850. APA PsycArticles. https://doi.org/10.1037/a0012657
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Hamlett, C. L., & Seethaler, P. M. (2011). Two-stage screening for math problem-solving difficulty using dynamic assessment of algebraic learning. *Journal of Learning Disabilities*, *44*(4), 372–380. APA PsycInfo. https://doi.org/10.1177/0022219411407867
Moscardini, L., & Moscardini, C. (2020). Dynamic assessment and teachers' knowledge of children's mathematical thinking: A case study in children's mathematics. *Support for Learning*, *35*(4), 522–541. APA PsycInfo. https://doi.org/10.1111/1467-9604.12331
Peltenburg, M., van den Heuvel-Panhuizen, M., & Robitzsch, A. (2010). ICT-based dynamic assessment to reveal special education students' potential in mathematics. *Research Papers in Education*, *25*(3), 319–334. Scopus. https://doi.org/10.1080/02671522.2010.498148
Popa, N. L., & Pauc, R. L. (2015). dynamic assessment, potential giftedness, and mathematics achievement in elementary school. *Acta Didactica Napocensia*, *8*(2), 23–31. Publicly Available Content Database; Social Science Premium Collection.
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2012). Predicting first graders' development of calculation versus word-problem performance: The role of dynamic assessment. *Journal of Educational Psychology*, *104*(1), 224–234. Scopus. https://doi.org/10.1037/a0024968
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2016). Does the value of dynamic assessment in predicting end-of-first-grade mathematics performance differ as a function of English language proficiency? *The Elementary School Journal*, *117*(2), 171–191. APA PsycInfo. https://doi.org/10.1086/688870

Wang, T.-H. (2014). Developing an assessment-centered e-Learning system for improving student learning effectiveness. *Computers & Education*, *73*, 189–203. APA PsycInfo. https://doi.org/10.1016/j.compedu.2013.12.002

Wu, H.-M., Kuo, B.-C., & Wang, S.-C. (2017). Computerized dynamic adaptive tests with immediately individualized feedback for primary school mathematics learning. *Journal of Educational Technology & Society*, *20*(1), 61–72. APA PsycInfo.

Figure 3

PRISMA flow diagram outlining the process of identification and screening of studies for the current review.



3.2.5 Assessing the Quality of Studies

The 14 included studies were subjected to assessment of methodological rigour and pertinence in relation to the research question specified. This was achieved by employing a framework to appraise weight of evidence (Gough, 2007). The framework suggests that in the discussion of the results of a systematic review, there should be more weight given to sources of evidence that are of higher overall quality and relevance. Accordingly, there are three domains that contribute to this overall assessment, quantified as weight of evidence A, B and C (WoEA, B & C). A description of each of these domains is as follows:

Weight of evidence A (WoE A): addresses how well the study was conducted in its own right without a view to how well it answers the specified research question.

Weight of evidence B (WoE B): The design of the study and how appropriate it is to provide evidence to answer the review-specific question.

Weight of evidence C (WoE C): The extent to which the aims and focus of the identified study align with the specific focus of the review question.

Weight of evidence D (WoED): an overall rating for the quality of the study and its relevance in answering the specified review question which is used to discern the weight that should be given to that evidence in the overall discussion.

An outline of the general scoring procedure is presented in Appendix 2. Examples of the scoring procedures used under WoEA are available at Appendices 3,4 and 5. An outline of the tiered system used to evaluate studies under WoEB is available at Appendix 6. Finally, an example of the scoring procedure under WoEC is available at Appendix 7. Total scores under WoE A, B, C and D for all included studies can be seen in Table 5.

Table 5

Scores attributed to each study for WoEA, B, C and D

Study	WoE A	WoE B	WoE C	WoED
Al-Hroub, A., & Whitebread, D. (2019).	1 (low quality)	1 (low quality)	1 (low quality)	**1 (low quality)**
Al-Hroub, A. (2021).	1 (low quality)	1 (low quality)	1 (low quality)	**1 (low quality)**
Bosma, T., Stevenson, C. E., & Resing, W. C. M. (2017).	2 (medium quality)	3 (high quality)	2 (medium quality)	**2.33 (high quality)**
Brownell, M. T., Mellard, D. F., & Deshler, D. D. (1993).	3 (high quality)	2 (medium quality)	1 (low quality)	**2 (medium quality)**
Cho, E., Fuchs, L. S., Seethaler, P. M., Fuchs, D., & Compton, D. L. (2020).	3 (high quality)	3 (high quality)	1 (low quality)	**2.33 (high quality)**
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Craddock, C. F., & Hamlett, C. L. (2008).	3 (high quality)	3 (high quality)	1 (low quality)	**2.33 (high quality)**
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Hamlett, C. L., & Seethaler, P. M. (2011).	3 (High quality)	3 (high quality)	1 (low quality)	**2.33 (high quality)**
Moscardini, L., & Moscardini, C. (2020).	2 (medium quality)	2 (medium quality)	3 (high quality)	**2.33 (high quality)**
Peltenburg, M., van den Heuvel-Panhuizen, M., & Robitzsch, A. (2010).	2 (medium quality)	1 (low quality)	2 (medium quality)	**1.66 (medium quality)**
Popa, N. L., & Pauc, R. L. (2015)	1 (low quality)	2 (medium quality)	1 (low quality)	**1.33 (low quality)**
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2012).	2 (medium quality)	3 (high quality)	1 (low quality)	**2 (medium quality)**
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2016).	2 (medium quality)	3 (high quality)	1 (Low quality)	**(2 medium quality)**
Wang, T.-H. (2014).	3 (high quality)	3 (high quality)	1 (low quality)	**2.33 (high quality)**
Wu, H.-M., Kuo, B.-C., & Wang, S.-C. (2017).	3 (high quality)	2 (medium quality)	2 (medium quality)	**2.66 (high quality)**

3.2.6 Extraction of Data

In total 14 studies were identified as meeting the inclusion criteria for analysis in the current systematic review. Out of the 14 studies identified, seven were appraised as constituting high-quality evidence in relation to the research question specified. Four of the studies were considered medium quality while three were considered low quality. The findings in relation to implementation of MDA in primary school samples are discussed with greater weight given to findings of studies deemed to be of higher quality.

3.2.6.1 Study Design. The majority of identified studies utilised a quantitative method to measure and compare learning potential. Some studies utilised a single sample research design to compare pre and post training test scores (Al-Hroub, 2021; Al-Hroub & Whitebread, 2019; Peltenburg et al., 2010). Alternatively, a mixed factorial ANOVA or multi-path analysis was employed to compare learning potential across groups (Bosma et al., 2017; Brownell et al., 1993; Cho et al., 2020; Popa & Pauc, 2015; Wang, 2014; Wu et al., 2017).

A further four studies used an analytical cross-sectional design to infer the predictive validity of MDA in relation to later mathematics achievement (Fuchs et al., 2008, Fuchs et al., 2011, Seethaler et al., 2012, Seethaler et al., 2016). These studies aimed to determine the amount of variance on a later test of mathematics achievement that could be attributed to learning potential while accounting for competing predictors such as language ability etc. The studies all bore common authors and used comparable designs. In such cases a cake design was used to index learning potential by a single score commensurate with the number of correct responses minus the level of explicitness of prompts administered in order to achieve this (Daneshfar & Moharami, 2018). Finally, one study employed a case study design to qualitatively analyse the outcomes of the implementation of the MDA process with a primary school pupil (Moscardini & Moscardini, 2020).

3.2.6.2 Participants. This synthesis included data from pupils from 1st grade to 8th grade. Geographically, the majority of studies were conducted in the United States, (*n*=6) but data was also obtained from samples in Jordan, the Netherlands, Taiwan and Romania. A mapping of the field consisting of details of each study relating participants, design and aims can be seen in Table 6.

Table 6

Mapping of the field consisting of description of sample, location, methodology and aims

Study	Sample	Location	Design	Aim
Al-Hroub, A., & Whitebread, D. (2019).	(N=30, F, 16, M14) Age: 10-11:11 5^{th} and 6^{th} graders	Jordan	Sandwich DA	Compare pre and post test scores of “twice exceptional students”
Al-Hroub, A. (2021).	(N=30, F, 16, M14) Age: 10-11:11 5^{th} and 6^{th} graders	Jordan	Sandwich DA	Compare pre and post test scores of “twice exceptional students”
Bosma, T., Stevenson, C. E., & Resing, W. C. M. (2017).	120 2^{nd} grade students, Experimental (N=60) and control groups (N=60)	Netherlands	Sandwich DA	Compare experimental and control groups and categorise children based on processes utilised according to prompts administered.
Brownell, M. T., Mellard, D. F., & Deshler, D. D. (1993).	20 children with learning disability and 20 matched low achieving 7^{th} and 8^{th} graders	Kansas, USA	Elements of both cake and Sandwich DA	Compare the task performance of two groups of children with and without assistance
Cho, E., Fuchs, L. S., Seethaler, P. M., Fuchs, D., & Compton, D. L. (2020).	368 1^{st} grade students English DA (N=187) Spanish DA (N=181)	Southeastern metropolitan region in the USA	Cake DA	Compare the learning potential of English and Spanish dominant EAL students with DA in both languages.
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Craddock, C. F., & Hamlett, C. L. (2008).	122 3^{rd} graders	USA 30 participating classrooms	Cake DA	Assess the predictive validity of learning potential of an algebraic task on later word problem solving.
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N.,	122 3^{rd} graders	USA 30 participating classrooms	Cake DA	To determine the utility of dynamic assessment as a predictor in reducing false positives for those identified as requiring learning support in maths.

Hamlett, C. L., & Seethaler, P. M. (2011).				
Moscardini, L., & Moscardini, C. (2020).	Single case study – 5-year-old girl Lara with maths difficulties	conducted in an area of high socio-economic deprivation	Individual interactionist approach	To provide a descriptive analysis of dynamic assessment sessions to uncover processes utilised by a case study
Peltenburg, M., van den Heuvel-Panhuizen, M., & Robitzsch, A. (2010).	8–12-year-olds 1-4 years behind their peer group in maths	Four special schools within Utrecht in the Netherlands	Pre-test, Support with digital manipulatives	To compare the scores of pupils on standardised tests of subtraction with performance with digital manipulatives. Also to determine which digital manipulatives aided with various processes used.
Popa, N. L., & Pauc, R. L. (2015).	50 primary school students between 6 and 7 years old	Romanian urban school	Sandwich DA	To assess whether dynamic assessment as a mode of interaction in a classroom would be a significant predictor of maths achievement.
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2012).	184 1st graders	southeastern metropolitan school district in USA	Cake DA	To determine the predictive validity of DA of an algebraic task on later word problem solving and calculation
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2016)	292 1st graders 129 LEP, 163 non-LEP	southeastern metropolitan area	Cake DA	to examine whether the predictive validity of DA in relation to Calculation and Word problem solving differed as a function of English language ability
Wang, T.-H. (2014).	107 6th graders	Recruited from 4 classes in Taiwan.	Sandwich DA	To test the effectiveness of individualised learning packages and prompts to improve maths achievement.
Wu, H.-M., Kuo, B.-C., & Wang, S.-C. (2017).	118 5th grade students	Taiwanese elementary school	Sandwich DA	To test the effectiveness of individualised learning packages and prompts to improve maths achievement.

3.2.6.3 Mathematics Tasks. The included studies employed a broad range of mathematics tasks as the subject of the dynamic assessment. Five of the studies utilised a similar algebraic task which required participants to solve for missing addends and complete equations (Cho et al., 2020; Fuchs et al., 2008, 2011; Seethaler et al., 2012, 2016). One study utilised the seria-think instrument which is an existing dynamic assessment tool based on the completion of series requiring planning, measuring and addition (Bosma et al., 2017). Similarly, a further study used a constructed 4-peg balance task requiring planning and addition strategies (Brownell et al., 1993). The remaining studies employed curriculum-based assessments. These mathematics tasks varied from understanding of the unit of speed in the curriculum (Wang, 2014), to adding fractions (Wu et al., 2017), subtraction crossing the 10 (Peltenburg et al., 2010) and broad multi-component curriculum-based assessments (Al-Hroub, 2021; Al-Hroub & Whitebread, 2019; Moscardini & Moscardini, 2020; Popa & Pauc, 2015)

3.2.6.4. Implementation of Dynamic Assessment. The dynamic approaches to assessment varied significantly across studies consistent with the observations of Caffrey et al., (2008). The majority of studies utilised a graduated prompts approach to dynamic assessment (Campione & Brown, 1987), which involves the administration of a number of set pre-determined prompts to support task completion (Al-Hroub, 2021; Al-Hroub & Whitebread, 2019; Brownell et al., 1993; Cho et al., 2020; Fuchs et al., 2008, 2011; Seethaler et al., 2012, 2016). This approach is rigid and allows for learning potential to be indexed by the amount or explicitness of prompts required to reach mastery or the degree of improvement achieved as a result of a set number of prompts (Fuchs et al., 2008). Also employing graduated prompts but in an individualised manner using computerised software were the studies conducted by Wang, (2014) and Wu et al., (2017).

Other studies utilised a graduated prompts approach to support mastery and determine the processes utilised by the student in undertaking the task (Bosma et al., 2017; Peltenburg et al., 2010). This fixed approach to dynamic interaction coupled with the aim of categorising students based on useful packages of prompts is referred to as “dynamic testing” (Elliott et al., 2018).

Two studies deviated from this methodology. One study utilised dynamic assessment that embraced the implementation of mediated learning experiences (Feuerstein et al., 2002), at a classroom level and assessed outcomes following an 8 week training block (Popa & Pauc, 2015). Finally, Moscardini and Moscardini (2020), documented an idiographic interactionist approach to dynamic assessment where the special education teacher was responsive to the student and attempted to gain an understanding of the processes employed by the student as well as potential useful interventions to support learning. Table 7 outlines the maths tasks and approaches to dynamic assessment for each of the included studies.

Table 7

Outline of the maths task and dynamic assessment approach employed by each study.

Study	Mathematics task	Dynamic element of administration
Al-Hroub, A., & Whitebread, D. (2019).	the Mathematical based skills scale (Waqfi, 1997) and the standardised national curriculum mathematics test. tasks included (a) calculation operations; (b) decimals ordering; (c) rounding up; (d) geometry; (e) algebra; and (f) problem solving.	Students were taught for three sessions (45 min for each) in three different groups.
Al-Hroub, A. (2021).	the Mathematical based skills scale (Waqfi, 1997) and the standardised national curriculum mathematics test. tasks included (a) calculation operations; (b) decimals ordering; (c) rounding up; (d) geometry; (e) algebra; and (f) problem solving	Students were taught for three sessions (45 min for each) in three different groups.
Bosma, T., Stevenson, C. E., & Resing, W. C. M. (2017).	Seria think instrument: Requires measuring and addition strategies to complete series	Graduated prompts based on 4 steps (1) determine depth, (2) plan the preferred height, (3) select the necessary rod and (4) complete the series. One or more protocols at each step consisting of metacognitive, cognitive, and modelling prompts. Scenario-protocols A-F were administered in training in response to participant's difficulties at each step.
Brownell, M. T., Mellard, D. F., & Deshler, D. D. (1993).	Series of balance scale tasks that involves addition and multiplication to discern whether the weights on either side will balance or not	Weighted graduated prompts adapted from (Day, 1988) were used for each task in the assisted conditions. Prompts were weighted by graduate students and ranged in explicitness. The number of prompts needed to reach mastery were measured.
Cho, E., Fuchs, L. S., Seethaler, P. M., Fuchs, D., & Compton, D. L. (2020).	Balancing equations dynamic assessment 4 types of equations A- Drawing circles to match Arabic number B- Solving missing number with one as an addend C- Solving missing number that does not have one as an addend. D- Sums on both sides of an equals sign	Three levels of prompts can be administered which include presentation of a completed equation along with a number line for use.
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Craddock, C. F., & Hamlett, C. L. (2008).	Balancing equations dynamic assessment 3 types of equations: A- finding the missing variable in the first or second position in addition equations (e.g., x+5=11 or 6+x=10) B- finding x in multiplication equations (e.g., 3x=9); and	Six levels of prompts can be administered. Including worked demonstrations of completed problems, explanation of terms etc.

	C- finding the missing variable in equations with two missing variables, but with one variable then defined (e.g., x+2=y−1; y=9).	
Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Hamlett, C. L., & Seethaler, P. M. (2011).	Balancing equations dynamic assessment 3 types of equations: A- finding the missing variable in the first or second position in addition equations (e.g., x+5=11 or 6+x=10) B - finding x in multiplication equations (e.g., 3x=9); and C- finding the missing variable in equations with two missing variables, but with one variable then defined (e.g., x+2=y−1; y=9).	Six levels of prompts can be administered. Including worked demonstrations of completed problems, explanation of terms etc.
Moscardini, L., & Moscardini, C. (2020).	Number of curriculum-based problems including counting, addition, subtraction, multiplication, division, algebraic reasoning	Idiographic and process related approach to dynamic assessment based on the principles of cognitively guided instruction.
Peltenburg, M., van den Heuvel-Panhuizen, M., & Robitzsch, A. (2010).	Two-digit subtraction tasks under 100 with units crossing the 10.	The use of digital manipulatives and digital number line
Popa, N. L., & Pauc, R. L. (2015).	Maths tests designed in accordance with the national curriculum in Romania.	Whole class implementation of dynamic assessment procedures based on Feuerstein's mediated learning experience over an 8-week period.
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2012).	Balancing equations dynamic assessment. 4 types of equations: A- 1 as a missing addend B- Missing addend which is not 1 C- Missing variable in the first position in subtraction equation D- Solve for missing variable in any 4 positions for sums on both sides of the equals sign.	Weighted Instructional scaffolding provided ranging from least explicit to most explicit prompts. Equation Types A and C have five levels of instruction, whereas Equation Types B and D have four. Scores range from 0-22, one point is deducted for each level of scaffolding provided before mastery is achieved. A score of 0 indicates mastery was not achieved on any equation type.
Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2016)	Balancing equations dynamic assessment 4 types of equations A- Drawing circles to match Arabic number B- Solving missing number with one as an addend C- Solving missing number that does not have one as an addend. D- Sums on both sides of an equal's sign	Three levels of prompts can be administered which include presentation of a completed equation along with a number line for use.
Wang, T.-H. (2014).	Speed unit of the elementary school mathematics course Concept of time, distance, speed, motion, calculation, and application of speed	Personalised dynamic assessment in the form of prompts administered by the computer based on the pre-test two tier diagnostic assessment
Wu, H.-M., Kuo, B.-C., & Wang, S.-C. (2017).	Addition and subtraction of fractions with different denominators	Personalised dynamic assessment in the form of prompts administered by the computer based on the pre-test two tier diagnostic assessment

3.2.7 Synthesising Data and Discussion

The final section of this systematic review synthesises the data from the included studies and discusses relevant findings. The theme that dynamic assessment represents great variety in the literature in relation to procedure and analysis is rife throughout this thesis and is endemic in this analysis. This variety leads to difficulties in synthesising relevant information from various sources and producing coherent and well supported claims. While the review question of "What has been found by employing a Mathematics Dynamic Assessment in empirical research in the primary school population?", is intentionally broad, it allows for multiple study designs and analyses to be reported here. In analysing and presenting findings it was determined that studies could be grouped and categorised to answer various questions that contribute to the overall review question outlined. Results of the included studies therefore are outlined in response to three further questions subsumed by the original review question. Greater weight in discussion is given to studies of higher quality of evidence.

Does mathematics dynamic assessment lead to the measurement of a learning potential construct?

Addressing this question is in line with the research oriented branch of studies which aim to quantify a learning potential construct which may inform educational policy etc. (Caffrey et al., 2008). Studies that aimed to measure learning potential in the general mainstream school population did so predominantly with children at the very start of their formal schooling (Fuchs et al., 2008, 2011; Seethaler et al., 2012, 2016). This was an appropriate design element as mathematics is often a hierarchically structured sequential subject where skills acquired in the previous module are required for navigation of the subsequent task (Chinofunga et al., 2023). This suggests that learning acquired by the pupil will inadvertently affect the potential to acquire new skills in this subject increasingly as they progress through school.

Evidence from confirmatory factor analysis suggests that initial potential to learn mathematics is a distinct factor from what the pupil can achieve on their own and this potential is also not explained by other latent variables such as language and attention (Fuchs et al., 2008). Moreover, not only is learning potential a distinct factor but it is also the best predictor of word problem solving (WPS) amongst these competing predictor variables (Fuchs et al., 2008; Seethaler et al., 2012, 2016). The principal analytic techniques used to determine these findings do not discount the possibility that learning potential has significant shared variance with the other predictor variables in explaining WPS scores. However, subsequent analysis suggests learning potential accounts for significant independent variance above competing predictors which may be as high as 12% (Cho et al., 2020; Seethaler et al., 2012). This is significant when considered amongst the array of predictors that also contribute to explaining variance in performance (Seethaler et al., 2012).

This evidence adds to a small body of research that has explored how learning potential can predict mathematics achievement at a later stage in a primary school sample. A review of three other studies that used a dynamic assessment of various domain general abilities suggests that learning potential explains more variance in outcome when the subject of the dynamic assessment aligns with the outcome measure (Fuchs et al., 2008). This suggests that learning potential is not universal across domains of learning. This is evidenced by a further finding in this area that dynamic assessment of decoding is predictive of word reading ability but not arithmetic at a later stage (Cho & Compton, 2015).

The practical significance of this body of work is illustrated by the finding that maths dynamic assessment can improve specificity by 57% when included as a measure to predict those in need of tier two intervention when holding selectivity to 87.5% (Fuchs et al., 2011). This finding is in keeping with the educability principle of dynamic assessment as alluded to by Haywood, (2012) by embracing the position that "does not do doesn't mean can't do". By altering the assessment paradigm, the rate of false positives in identification of those in need of intervention was reduced.

This potential is particularly relevant when trying to identify etiological subgroups who score low on static tests of mathematics achievement for different reasons. For example, English language learners (ELLs) may fail to complete word problems correctly, but this may be due to difficulty with comprehension of the language component of the task as opposed to the correct application of computational methods. Assessment of a mathematics task where prompts are administered to help with the language component of the word problem is a better predictor of WPS at a later stage than a test of vocabulary and a static mathematics test for this group (Seethaler et al., 2016). Moreover the language of administration is an important component as, for ELLs that exhibit dominance in another language, dynamic assessment can produce a differential boost for them when the DA is administered in their language of preference (Cho et al., 2020). That is to say ELLs who are Spanish dominant can improve their performance to equal those who are English dominant ELLs who are receiving DA in English, but this effect is not observed for Spanish dominant ELLs receiving DA in English. This research is again in line with the educability principle of dynamic assessment as alluded to by Haywood (2012) as the aim of the research is to uncover the assessment conditions that result in uncovering potential.

Can Maths Dynamic Assessment lead to improvement in maths achievement?

Answering this question is in line with the clinically oriented branch of studies that emphasise the clinical applications of dynamic assessment and not the measurement of learning potential constructs to inform policy-making (Caffrey et al., 2008). These studies employ a sandwich design and measure the difference between pre-test and post-test scores following a mediation phase (Popa & Pauc, 2015; Wang, 2014; Wu et al., 2017). Application of a maths dynamic assessment with children who are low achieving in maths has provided evidence of positive outcomes. Mediation can lead to improvement of planning and meta-cognitive factors in a maths related task within this group; however there were mixed findings in this research as number of insertions in the seria-think task did not decrease significantly following mediation (Bosma et al., 2017).

In comprehensive research conducted by Wang (2014), individualised dynamic assessment and electronic learning material were informed by a two-tier diagnostic assessment which interprets the misconceptions of students. This individualised approach was found to improve mathematics attainment and decrease misconceptions of students in the learning of the speed module. Significantly this research has also found a differential boost for those with low level mathematics knowledge prior to the assessment process. The research indicates that individualised dynamic assessment improves performance for this group above generalised prompts and learning materials; however there are no such differences found for those with high level knowledge prior to assessment (Wang, 2014). These results were corroborated by a similar computerised approach to implementation of dynamic assessment in addition and subtraction of fractions which was found to be more effective than generalised prompts in improving performance (Wu et al., 2017).

How does employment of Mathematics Dynamic Assessment inform researchers of the procedural and conceptual understanding of the participant?

The majority of included studies in this review were outcomes focused, however a number of studies did allude to an analysis of processes by the participants. Peltenburg et al.

(2010) found that students could be grouped according to the strategy they were using to complete double-digit subtractions that crossed the ten and that the strategy they used could be discerned by the degree to which various digital manipulatives boosted their performance. Similarly, Bosma et al., (2017) found that the children could be grouped according to their processes which could be inferred by analysing which set of delivered prompts most effectively boosted performance. This quantitative approach to inferring the processes utilised by students is referred to as dynamic testing (Elliott et al., 2018).

The only study that employed qualitative analysis from a case study design to provide an in-depth analysis of the processes of the pupil was conducted by Moscardini and Moscardini (2020). This qualitative analysis found that a number of inferences can be made about the participants' abilities through the interaction between examiner and examinee. For example, inferences can be made about concept of number, understanding of mathematics language and strategies used for computation by observing and asking the participant to verbalise their processes. In this case the counting all method of addition was identified to be used by the participant to complete a simple addition task using concrete materials (Geary, 2011). This mode of interaction allows for something akin to a task analysis with the participant to discover the steps involved in successful completion of the task. Furthermore, the study found that utilisation of a host of materials such as counters, whiteboards and markers was essential to allow the participant to work along the concrete to abstract continuum (Allsopp et al., 2008), at a level commensurate with their zone of proximal development (Vygotsky & Cole, 1978).

A further key finding is that dynamic assessment allows for the analysis of procedural knowledge and conceptual understanding, two of the five elements determined to underlie mathematics proficiency (Dunphy et al., 2014). For example, one word problem conveyed a sum of 2+9 to be completed. The participant used her number line to complete the task as a procedure which she had been taught. However, she did not complete the procedure correctly and her inability to recognise the answer was incorrect showed a conceptual misunderstanding. An overreliance on procedural strategies that are not underpinned by conceptual understanding are common in children with mathematics difficulties which may arise from an underdeveloped concept of number according to the model outlined by von Aster and Shalev (2007) in the introduction (Butterworth, 2005, 2010, 2018). An individualized approach to dynamic assessment allows for a more in-depth analysis of these processes. Moscardini and Moscardini (2020) suggest that understanding the details of children's mathematical thinking is central to supporting them in their learning which is congruent with the principles of dynamic assessment (Haywood, 2012; Haywood & Lidz, 2007).

3.3. Summary of Findings

The current systematic review was conducted with the aim of identifying and analysing studies that employed a MDA procedure with primary school aged children. The majority of these studies implemented a study design that emphasised a nomothetic approach to allow for the quantification of learning potential (Beltz et al., 2016). These study designs focus either on analysing the effectiveness of mediation in improving achievement or aim to quantify learning potential as a latent variable, referred to as clinically-oriented and research-oriented dynamic assessment respectively (Caffrey et al., 2008). Studies that adopted a research-oriented approach represent the greatest methodological rigour of all categories of studies. Findings from these studies suggest there is good quality evidence to show that learning potential in mathematics is a factor that is distinct from mathematics achievement as measured through static testing at the beginning of a child's formal schooling (Fuchs et al., 2008). Implementing dynamic assessment to identify those in need of tier two intervention can also reduce the rate of false positives and save valuable time and resources within schools

(Fuchs et al., 2011). Clinically-oriented designs also suggest that MDA can produce significant improvements in mathematics performance with individualised prompts and learning materials effective at both the procedural and conceptual levels (Wang, 2014; Wu et al., 2017).

Finally, the qualitative analysis of the implementation of individualised MDA with a pupil exhibiting mathematics difficulties can be effective in highlighting procedural and conceptual processes used to complete tasks (Moscardini & Moscardini, 2020). Despite this preliminary finding there is an identified dearth of literature that employs these investigative methods. Of note, the case study design employed by Moscardini and Moscardini (2020) involved the use of a descriptive analysis. The current review therefore identifies a need to further explore qualitative analysis of MDA procedures which are theoretically informed and in line with the principles outset by Haywood (2012), to discern how these methods may be employed in the primary school context and what can be learned from such an approach.

3.4. Chapter Conclusion

This chapter builds on the context and policy background provided in chapter 2. The overview given in chapter 2 suggests that there is a congruency between the theoretical foundations of dynamic assessment and approaches to mathematics education in Ireland. A systematic literature review was then carried out in this chapter to discern what is already known in the area of mathematics education in primary schools and dynamic assessment. A systematic search, screening and appraisal of literature across five relevant databases resulted in the identification of 14 studies, seven of which were considered to be of a high standard to address the current research question. Findings from these identified studies suggest that learning potential in mathematics is a useful construct to consider in line with a research-oriented approach to dynamic assessment (Fuchs et al., 2008, 2011; Seethaler et al., 2012, 2016). Individualised, computerised prompts acting as scaffolding can also result in significant improvements in mathematics achievement (Wang, 2014; Wu et al., 2017).

Significantly, only one published study utilized an individualized approach to dynamic assessment that was responsive to the needs of the learner (Moscardini & Moscardini, 2020). This study didn’t emphasise outcomes or measuring of constructs, but was process focused in line with the principles of dynamic assessment (Haywood, 2012). While this study provides valuable insights into how to implement an individualized approach to MDA in a primary school setting, the analysis of the data that arose from this process was descriptive in nature. The current review therefore highlights the need for more high-quality data that examines an interactionist form of dynamic assessment that is more closely rooted in the theoretical frameworks that underlie this approach.

4. Empirical Chapter

4.1. Overview

This chapter outlines the investigation and data analysis undertaken in answering the research question defined as a result of the findings of the systematic review completed in the chapter 3. This chapter begins by overviewing the results of the systematic review detailed in the previous chapter as well as defining theoretical constructs pertinent to the current investigation in section 4.2. The overview will give an account of central components of the theory of structural cognitive modifiability (Feuerstein et al., 1988), which will encompass mediated learning experiences and core learning functions (Feuerstein et al., 2002; Tzuriel, 2013). The overview will also allude to findings from existing literature implementing this approach to fostering learning. This section concludes with the clear outline of the current research question.

The methods of the investigation are then described in section 4.3 beginning with the recruitment process to obtain the pilot and subsequent case studies before outlining core elements of the design. Yin (2009) proposes six elements to case study design which are thoroughly addressed in this section. The final of these six elements is a case study protocol which necessitates the outlining of procedures and measures used relevant to the design. In the current investigation the procedure is informed by the Special Education Support Service framework for maths dynamic assessment. A range of concrete and supplementary materials are used to support learning in flexible interviews with the pupils similar to the approach used by Moscardini and Moscardini (2020) in the outlining of their case study. Various types of qualitative data were collected in the course of the procedure including abstract level assessments, error pattern analyses, transcribed video recordings of dynamic assessment sessions as well as teacher and student semi-structured interviews

A description of how this qualitative data was analysed is then provided in section 4.4. The data is analysed in accordance with theoretical propositions which address the overarching research question consistent with Yin's framework (2009). The analysis is deductive in nature, informed by definitions of core learning functions and mediated learning experiences offered by checklists from the Dynamic Assessment UK organisation (*DA Learning Resources*, n.d.). Pattern matching analysis is then used to assess to what extent the empirical data is consistent with patterns predicted by the theories of the zone of proximal development (Vygotsky & Cole, 1978), and structural cognitive modifiability (Feuerstein et al., 1988). Reference to measures taken to increase the reliability and validity of the investigation are then outlined in sections 4.5 and 4.6, respectively.

An overview of the findings from the pilot investigation that informed changes to the design of the study are outlined in section 4.7. Findings are then presented in section 4.9, and this is done by reviewing individual cases first and then using a cross-case synthesis. During the cross-case synthesis, findings of the current analysis are related back to key arguments and positions within the literature. The discussion outlines the relevance of findings and distinguishes to what extent the identified gap in the literature has been addressed.

4.2. Overview of Theoretical Concepts

The current empirical investigation concerns the dynamic assessment of maths tasks (MDA). Empirical data exploring the outcomes of the implementation of MDA procedures are limited as per the findings of the systematic review conducted in the previous chapter. Published empirical research that has explored this phenomenon has provided evidence to support a narrow range of conclusions. For example, implementation of a MDA provides evidence that a learning potential construct assessed by performance assisted by set pre-determined prompts, is independent of static ability in early school years and this learning potential construct is a better predictor of later maths attainment than static measures (Fuchs et al., 2008, 2011; Seethaler et al., 2012). Moreover, individualised computerised dynamic assessment which administers prompts to answers based on error analysis results in greater improvement in maths attainment than generalised prompts (Wang, 2014; Wu et al., 2017).

A subset of identified studies were process focused. Two of these used a nomothetic approach to categorise participants based on the processes they utilised for task completion which was inferred from their performance aided by certain prompts.(Bosma et al., 2017; Peltenburg et al., 2010). Only one study utilised an individualised interactionist approach to dynamic assessment to obtain a greater understanding of the pupils maths conceptualisations (Moscardini & Moscardini, 2020).

While the majority of studies acknowledge the contribution of Reuven Feuerstein to the development of dynamic assessment, few incorporate multiple elements of his theory of structural cognitive modifiability as part of their research design. Many interpretations of this influence stop at an acknowledgement of the importance of a mediator to interpose themselves between the learner and the stimulus to promote learning and development (Feuerstein et al., 2002; Tzuriel, 2013). Only one study incorporated characteristics of mediated learning experiences, and did so at a whole class level as part of the methodology to determine the effectiveness of such an approach to fostering learning (Popa & Pauc, 2015). The current investigation gives consideration to the core learning functions and mediated learning experiences that are central to the theory of structural cognitive modifiability identified by Feuerstein (Feuerstein et al., 2002). An analysis of these constructs as they pertain to the current research design is provided.

4.2.1. Structural Cognitive Modifiability

Consideration of the theory of structural cognitive modifiability (SCM) (Feuerstein et al., 1988) adds depth to the interpretation of the concept of dynamic assessment. What was distinct about Feuerstein's teachings was the inherent focus on how children acquired the psychological tools to learn, in opposition to the more common practice of comparison of skills or knowledge already acquired (Feuerstein et al., 1991). Feuerstein conceptualised intelligence as the adaptability of the individual to its environment, or the ability of the individual to modify its own cognitive structures (Tzuriel, 2013). This alternative conceptualisation of intelligence arose from a comparison of "culturally different" and "culturally deprived" groups. The observations of these groups suggested children that grew up in a different culture and those that grew up without appropriate mediation through trauma or neglect, scored significantly lower than children embedded within a culture on culturally relevant standardised tests. The key distinction between the two aforementioned groups however was that culturally different children quickly adapted to improve their scores through direct interaction with the environment while culturally deprived children did not (Feuerstein et al., 1991). The deduction from these observation was that although culturally different children had not acquired the skills/knowledge of the new culture, they could acquire the new skills through interaction with the environment because they had acquired the psychological tools needed to learn (Feuerstein et al., 1991). The learning or development of internalised systems which is a result of indirect or mediated learning equips the learner to autonomously learn through direct interaction with the environment (Tzuriel, 2013). Feuerstein identified core learning functions and quality of mediated learning experiences that were central to the development of these autonomous learners (Lauchlan & Daly, 2023). These concepts are considered in the current research design and are defined here.

4.2.1.1. Core Learning Functions. The propensity of the individual to learn is dependent on the cultural transmission of learning tools, habits and dispositions (Bodrova & Leong, 2007; Feuerstein et al., 1991). Dynamic assessment offers an opportunity, through the interaction between examiner and learner, to analyse these core cognitive functions which are categorised in three phases of thinking: input, elaboration and output (Rosen, 2019). Deficient functions at input make it difficult to determine the salient features of the task, while deficient functions in elaboration make it difficult to organise and plan strategies in accordance with task demands. Finally, deficient functions at the output stage may manifest as imperfect communication of response and impulsivity (Esterhuizen, 2014). The cognitive functions identified by Feuerstein align closely with what are now considered to be executive functions and are generalised components of problem-solving behaviour (Lauchlan & Daly, 2023). The evaluation of these learning functions as a propensity to learn holds promise as an avenue for more culturally fair assessment practices in education consistent with the original observations of Feuerstein who observed the propensity of the culturally different group of children to adapt to their new environment (Feuerstein et al., 1991).

4.2.1.2. Mediated Learning Experiences. A mediated learning experience is a particular type of interaction that fosters cognitive modifiability recognised when a teacher or an adult interposes themselves between the learner and a stimulus (Tzuriel, 2013). Feuerstein identified 11 characteristics of mediated learning experiences (as cited by Lauchlan & Daly, 2023), these are:

1. Intentionality and reciprocity
2. Meaning
3. Transcendence
4. Feelings of competence
5. Regulation and control of behaviour

6. Sharing
7. Individuation and psychological differentiation
8. Goal setting, goal seeking and goal achieving
9. Challenge
10. Change
11. Optimistic alternative

Mediated learning experiences allow the child to internalise learning mechanisms, facilitate learning processes through self-mediation, and develop deficient cognitive functions (Passig et al., 2016). A body of research has explored the relationship between these qualities of interaction and cognitive development affirming their relevance and significance. Correlational data suggests measures of mediated learning experiences between parent-child dyads is related to cognitive performance in typically developing children and children with learning disabilities and may be related to socio economic status (Russell et al., 2008; Tzuriel & Shomron, 2018; Tzuriel, 1996). Tzuriel (2013) reviews a body of data suggesting that mediated learning experiences between mother-child dyads as measured by observational tools with good reliability were predictive of modifiability of children or responsiveness to guidance on a progressive matrices task. Moreover, Klein (1991) found a low intensity 7 month intervention significantly improved mediation skills of parents of babies of low birthweight, and compared to a control group these children had significantly higher cognitive scores at follow up. The relationship between mediated learning experiences and modifiability or adaptability has also been observed in teacher-student dyads (Tzuriel et al., 1999; Tzuriel & Remer, 2018) and peer dyads (Tzuriel & Shamir, 2007).

4.2.1.3. Relevance to Current Investigation. The current investigation is an exploration of the implementation of a mathematics dynamic assessment procedure in an educational setting. The systematic literature review identified a dearth of literature in the area of dynamic assessment and maths and suggests no study has implemented a qualitative design to explore the implementation of such an approach informed by theoretical underpinnings i.e. the zone of proximal development (Vygotsky & Cole, 1978) and structural cognitive modifiability (Feuerstein et al., 1988).

Most studies identified through the systematic review of the literature endorsed the zone of proximal development (Vygotsky & Cole, 1978) as the theoretical underpinnings of the design. Most studies also embraced the importance of a mediator to interpose themselves between the environment and the individual to facilitate learning as part of the theory of structural cognitive modifiability (Feuerstein et al., 1988). The theory of SCM however encapsulates a broader vision to assess the learning propensity of the child by evaluating core cognitive functions that are central to general problem solving and the receptiveness of the child to mediation (Lauchlan & Daly, 2023). The current study is novel in incorporating these elements of Feuerstein's theory along with an analysis of the zone of proximal development to assess how such an approach can facilitate learning in an educational setting for children exhibiting maths difficulties.

4.3. Methods

4.3.1. Design

The design of the project is informed by Yin's case study methodology (2009) and consists of a pilot and two case studies. Each case was composed of a student, a class teacher and a special education teacher. Cases were intended for literal replication to improve reliability (Quintão et al., 2020). A case study approach was deemed appropriate for the current exploration for a number of reasons.

Firstly, dynamic assessment is a complex phenomenon, which, in accordance with its true essence is neither wholly assessment nor intervention but is an individualised approach adopted to respond to the needs of the learner (Haywood, 2012). Yin (2009), states there are at least four reasons to conduct case study, the most important presumably being to explain causal links in real life interventions that are too complex to be fully captured by survey or experimental data. The current investigation aims to link complex multi-faceted modes of interaction or mediated learning experiences to changes in understanding or reconceptualization in the school setting.

Secondly, experimental investigations attempt to completely boundary a phenomenon from its context to allow for changes in outcomes to be attributable to any experimental manipulations. A case study design is used to explain a phenomenon in its real-life context and is more suited where the boundary between phenomenon and context is blurred (Yin, 2009). The current investigation therefore does not attempt to isolate this phenomenon for investigation but rather acknowledges as part of its design, and aims to comment on MDA in the context of national educational policy, national curricula, teacher training and expectations, input of external services and models of service delivery etc.

4.3.2. Participants

Three pupils with mathematics difficulties were recruited in accordance with inclusion and exclusion criteria detailed for the current study. Each case consisted of a triad of a pupil, class teacher and special education teacher. The latter two case studies were recruited from the same school as the teacher who responded discussed both cases and both were adjudged to meet the inclusion criteria. Therefore, while each case consisted of a triad of a student, a class teacher and special education teacher in the latter two cases both students shared the same special education teacher. School principals, teachers, and parents of pupils were presented with information letters and consent forms prior to agreeing to partake in the study (See Appendices 8-13). The pupil was presented with an information sheet and assent form after recruitment (See Appendices 14-15) For details regarding the recruitment procedure and inclusion/exclusion criteria see Appendix 16. An overview of the three cases can be seen at Table 8.

Table 8

Descriptive information for each case

Participant	Pseudonym	Class	School	Class teacher (pseudonym)	SET (pseudonym)
Pilot	Peter	2^{nd} class	X	Ms. Mannion	Ms. Heaney
Case 1	Louise	5^{th} class	Y	Ms. O'Hara	Ms. Mullins
Case 2	Sarah	2^{nd} class	Y	Ms. Beirne	Ms. Mullins

4.3.3. Components of a Case Study

There are six central components for consideration when conducting a case study according to Yin (2009), as listed below. Each of these components are addressed in this section.

1. Research question
2. Theoretical propositions
3. Unit(s) of analysis

4. Logic linking the data to the propositions

5. Criteria for interpreting the findings

6. Case study protocol

4.3.3.1. Research Question. The research question was formulated from consulting the literature in the areas of both mathematics education and dynamic assessment. A systematic literature review conducted in the previous chapter collated studies that investigated dynamic assessment procedures of mathematics tasks. A number of studies have utilised a nomothetic, quantitative approach to explore this phenomenon (Fuchs et al., 2008; Seethaler et al., 2012, 2016; Wang, 2014; Wu et al., 2017). However, there is a distinct lack of qualitative data exploring how an individualised, interactionist approach to mathematics dynamic assessment can be used to support a student with mathematics difficulties. Moreover, no study has used a theoretically informed approach to the qualitative analysis of a MDA procedure. The research question therefore is:

How can the implementation of a mathematics dynamic assessment help support children exhibiting mathematics difficulties in the Irish primary school context?

4.3.3.2. Theoretical Propositions. Theoretical propositions are often used as part of a case study design to focus the investigation in the technically distinctive situation where there will be many more variables of interest than data points (Yin, 2009). Propositions are based on a theoretical framework or a proposed blueprint that speculates or attempts to provide answers to the outlined research question. By stating theoretical propositions, it allows for the investigation to move in the right direction and orient attention to that which should be analysed within the study (Yin, 2009). The data obtained in addressing theoretical propositions is then generalised and gives strength to these theories (analytic generalisation) as opposed to being generalized to a population (statistical generalisation) (Yin, 2009).

The theoretical blueprints to address the research question of “How can the implementation of a mathematics dynamic assessment help support children exhibiting maths difficulties?” are informed by the zone of proximal development as a concept arising from socio-cultural theory (Vygotsky & Cole, 1978) and structural cognitive modifiability (Feuerstein et al., 1988). These theoretical frameworks are inherently linked with the concept of dynamic assessment and therefore offer a blueprint to explain the causal links in this complex interaction as is the purpose of the case study (Yin, 2009).

The adoption of both frameworks in the design adds depth and contributes to the originality of the current investigation. While the ZoPD underlies all dynamic assessment procedures, the adoption of this framework in isolation in the current design would result in propositions that would potentially apply to a broad range of observations. In contrast the theory of SCM is more narrow in focus and does not apply to all cases of what is referred to as dynamic assessment (Elliott et al., 2018).

The theory of SCM as originally proposed by Feuerstein suggests that the implementation of mediated learning experiences is with the aim of targeting deficient core learning functions which enhances the propensity of the pupil to learn (Feuerstein et al., 1991; Tzuriel, 1992).Lauchlan and Daly (2023) suggest this original terminology is deficits-based and advise that the theory should be portrayed using strengths based terminology. This is acknowledged here and reflected in the phrasing of theoretical propositions in this investigation. For example, the first theoretical proposition reads:

“MDA will enhance domain general learning functions following the implementation of mediated learning experiences consistent with the theory of SCM."

As alluded to in section 2.5, dynamic assessment also pertains to curriculum-based tasks and enhances domain specific learning. The literature suggests that there are two ways in which the implementation of mediated learning experiences may enhance domain specific learning (Lauchlan & Daly, 2023; Passig et al., 2016):

1) The individual may internalise mediated learning experiences directly such as scaffolding or explicit help provided by the examiner.

2) The enhancement of domain general learning functions due to mediated learning experiences improves the ability of the individual to learn directly from their environment and so obtain domain specific knowledge or skills.

While either or both proposals may be relevant, both result in the same outcome. Therefore, the second theoretical proposition in this investigation is phrased to encompass both of these eventualities. The second theoretical propositions reads:

“MDA will result in the student’s reconceptualization of maths concepts that follows mediated learning experiences consistent with the theory of SCM.”

The third and fourth propositions relate to the theory of the ZoPD. This theory suggests that there are things an individual can achieve on their own, things they can achieve with support and things they can not achieve at this time (Vygotsky & Cole, 1978). Finally, the fifth theoretical proposition suggests that the MDA will provide the teacher with useful recommendations informed by both the theories of SCM and ZoPD. The five theoretical propositions are as follows:

1) MDA will enhance domain general learning functions following the implementation of mediated learning experiences consistent with the theory of SCM.

2) MDA will result in the student's reconceptualization of maths concepts that follows mediated learning experiences consistent with the theory of SCM.

3) The MDA procedure will illustrate domain general constructs (affective and cognitive) that are under-developed, well developed and in the zone of proximal development.

4) The MDA procedure will illustrate domain specific (maths) constructs that are under-developed, well developed and in the zone of proximal development.

5) MDA will provide practical information to the teacher in relation to the student informed by theories of the zone of proximal development and structural cognitive modifiability.

4.3.3.3. Unit of Analysis. The unit of analysis is the focus of the study as a topic or phenomenon to be explored. Crucial to this definition is the distinction that a case study has both substance and form, i.e. what the study is about and what question is being asked (Yin, 2009). In the current case the unit of analysis is mathematics dynamic assessment. The form of the investigation asks how this phenomenon can be used to support students with mathematics difficulties.

4.3.3.4. Logic linking data to Propositions. Various types of data were collected to address each of the defined theoretical propositions (Yin, 2009). The main data sources collected for each case were two videoed flexible interview sessions, which constituted the dynamic interactions between the researcher and pupil. Various other types of data were collected including an initial student interview to determine their interests (for template see Appendix 17) and a teacher consultation to determine what areas of the maths curriculum the student may be having difficulty with (for template see Appendix 18). An abstract level assessment was then carried out to determine the pupil's level of achievement in various strands of the mathematics curriculum. An error pattern analysis was conducted in response to this assessment to interpret potential misconceptions. Following completion of the two flexible interview sessions, semi-structured interviews with teachers, special education teachers and students were carried out. A research journal was also maintained throughout the process to separate empirical observations from researcher interpretation (Yin, 2009). How each type of data relates to each stated theoretical proposition is listed below in Table 9.

Table 9

Data source that relates to each theoretical proposition

Proposition	Type of Data
1) MDA will result in a change in domain general processes that follows a mediated learning experience consistent with the theory of SCM.	• Teacher consultation • abstract level assessment and error pattern analysis • transcribed video of flexible interview sessions, • semi-structured interviews from student
2) MDA will illustrate reconceptualization of maths concepts that follows a mediated learning experience consistent with the theory of SCM.	• Teacher consultation • abstract level assessment and error pattern analysis • transcribed video of flexible interview sessions, • semi-structured interviews from student
3) The MDA procedure will illustrate domain general constructs (affective and cognitive) that are under-developed, well developed and in the zone of proximal development.	• Teacher consultation • abstract level assessment and error pattern analysis • transcribed video of flexible interview sessions, • semi-structured interviews from student
4) The MDA procedure will illustrate domain specific (maths) constructs that are under-developed, well developed and in the zone of proximal development	• Teacher consultation • abstract level assessment and error pattern analysis • transcribed video of flexible interview sessions, • semi-structured interviews from student
5) MDA will provide practical information to the teacher in relation to the student informed by theories of ZoPD and SCM.	• Teacher and special education teacher semi-structured interview

The types of data relevant to address each proposition are deemed appropriate for the following reasons:

- A number of previous studies have analysed recordings from parent - child interactions (Klein, 1991; Russell et al., 2008; Tzuriel & Shomron, 2018; Tzuriel, 1996) and from teacher – student interactions (Tzuriel & Remer, 2018) to determine the extent to which these were consistent with the specifications of a mediated learning experience and relating these ratings to cognitive outcome measures. A comparative qualitative approach is adopted here.
- The initial abstract level assessment and error pattern analysis provides evidence of any misconceptions students have in relation to mathematical concepts and can be coded to support later evidence of structural cognitive modifiability or underdeveloped constructs.
- Semi structured interviews are used to triangulate observations of mediated learning experiences and structural cognitive modifiability and determine what elements of the MDA were found to be useful. Collecting various forms of data from multiple informants is in keeping with a key principle of data collection proposed by Yin (2009), which is to assess for triangulation.
- Finally, a research journal was documented as Yin (2009) suggests separating recorded empirical observation and researcher interpretation is of central importance to improving reliability.

4.3.3.5. Criteria for Interpreting Findings. In qualitative research the validity of findings depends on the researcher's presentation of sufficient evidence along with a rigorous and systematic approach to consideration of alternative causal explanations (Yin, 2009). The general analytical approach in the current investigation is centred on theoretical propositions. Pattern matching and thematic analysis are employed to address each proposition.

Braun and Clarke's (2006) phases of thematic analysis were completed to identify relevant core learning functions related to the student's attainment in mathematics. These learning functions are domain general and consistent with constructs identified by Feuerstein and colleagues (Feuerstein et al., 1991, 2002; Lauchlan & Daly, 2023). Domain specific learning functions were identified with the aid of outlined mathematical concepts as part of the new primary mathematics curriculum in Ireland (National Council for Curriculum and Assessment, 2023). Thematic analysis was also employed to identify the frequency of characteristics of mediated learning experiences (Feuerstein et al., 2002) observed in the interactions between the researcher and the student.

Pattern matching was used to identify empirical evidence within the data which is consistent with theoretical frameworks and propositions. Pattern matching compares an empirically based pattern with a predicted one (arising from theory and propositions) and if the patterns match, it strengthens the study's internal validity (Yin, 2009). Pattern matching is used to assess the extent to which the empirical data approximates the patterns predicted by the theories of the zone of proximal development (Vygotsky & Cole, 1978) and structural cognitive modifiability (Feuerstein et al., 1988).

4.3.3.5. Case Study Protocol. A case study protocol enhances the reliability of a multiple case study design (Yin, 2009) and outlines the procedure to be followed. The process of the current investigation is informed by the framework for maths dynamic assessment published by the Special Education Support Service (SESS). The framework outlines distinct stages in carrying out a maths dynamic assessment which consists of six steps. For the purpose of the current investigation an extra step was added which was the use of an intake interview (See Appendix 17 for template) adopted from a paper by Allsopp et al. (2008) to discern student interests. This information was to be incorporated into flexible interview sessions to improve motivation and engagement throughout the process. The seven steps that informed the current procedure therefore are listed in Table 10 below.

The result of the dynamic assessment process was a short, written summary provided to the class teacher and SET which was discussed in a feedback session. Semi-structured interviews were conducted with the student, class teacher and SET following the completion of these sessions to gain their perspectives and evaluation of the mathematics dynamic assessment process (for interview schedules see Appendices 19 and 20)

Table 10

The Special Education Support Service Maths dynamic assessment framework. Note that step 2 is adapted from Allsopp's (2007) framework

Stage	Action
1.	Target the particular maths concepts/skills you are interested in evaluating. (conduct an initial consultation with teachers)
2.	Conduct an intake interview to specify the student's strengths and interests
3.	Develop an abstract level assessment of target concepts/skills that includes at least 5 to 10 items for each target maths concept/skill.
4.	Evaluate whether students are at a mastery level (90-100% accuracy), instructional level (75%-89%), or frustration level (below 75%) using the abstract level assessment.
5.	For concepts/skills that the student is not at a mastery level, conduct an error pattern analysis.
6.	Based on your findings, conduct a flexible maths interview to get a picture of your student's mathematical thinking and understanding of selected maths concepts/skills (include use of concrete materials and/or drawings).
7.	Use the information gained to: Select appropriate concepts/skills for instruction, including any prerequisite concepts/skills (e.g., place value). Determine what level of understanding instruction should first incorporate (e.g., concrete, representational/semi-concrete, abstract). Teach conceptual understanding and procedural understanding.

4.3.4. Measures

A number of measures were used in the course of the MDA process. Abstract level assessments were taken from published curriculum-based measures commensurate with the level the student was working at. Texts used for this purpose included “Figure it out 1”, “Busy at Maths 2nd class Shadow Book” and “Figure it out 5”. Relevant checklists were used to identify the domain general cognitive constructs purported to underlie learning propensity. Checklists published by Dynamic Assessment UK (Appendix 21) which is endorsed by the British Psychological Society (*DA Learning Resources*, n.d.) were used for this purpose. The checklist consists of affective factors related to learning such as concentration and motivation, and cognitive factors such as planning, communication etc. The checklist is based on the work of Feuerstein, Feuerstein, Falik, and Rand's (2002), list of deficient cognitive functions, and Tzuriel, Samuels, and Feuerstein's (1988) list of non-intellective factors (as cited by Lauchlan, 2012).

Identification of relevant domain specific factors was informed by strands and learning concepts outlined by the new primary mathematics curriculum (National Council for Curriculum and Assessment, 2023). Finally, mediated learning experiences were identified with the use of a second checklist published by the Dynamic Assessment UK group (see Appendix 22). The checklist consists of 17 characteristics of mediated learning experiences based on Feuerstein's original 11, and with others added by practitioners with over 40 years of experience (Lauchlan & Daly, 2023)

4.4. Data Analysis

Responses from the initial teacher consultation and student initial interview were documented by the principal researcher. Photographs of abstract level assessments were taken and uploaded to a word document. An error pattern analysis was conducted by analysing incorrect responses and recording an interpretation of potential misconceptions or procedural inaccuracies. Video recordings of flexible interviews were then transcribed including pauses and other non-verbal responses. Semi-structured interviews were also transcribed. Teacher consultations, error pattern analyses, transcribed video recordings of flexible interviews and teacher and student semi-structured interviews were then uploaded to Nvivo 12 qualitative analysis software for analysis.

4.4.1. Thematic Analysis

Thematic analysis was employed to identify learning functions and characteristics of mediated learning experiences pertinent in each case. This analysis was deductive in nature, conducted to systematically identify pre-determined themes. These themes related to cognitive and affective learning functions, and mediated learning principles informed by Dynamic Assessment UK checklists (*DA Learning Resources*, n.d.) and learning objectives outlined in the new primary mathematics curriculum (National Council for Curriculum and Assessment, 2023) across each participant's dataset.

Following the methodological framework outlined by Braun and Clarke (2006), the analysis proceeded through five stages. Firstly, familiarisation involved immersing in the data to gain a comprehensive understanding of the content. Next, initial codes were generated by systematically labeling segments of the data relevant to the predefined themes of cognitive learning functions, affective learning functions, mathematical concepts and mediated learning experiences. This was followed by a thorough review to ensure consistency and clarity in each identified theme. Once the themes were finalised, they were again compared with the definitions provided by checklists and curriculum documents. Finally, the themes were systematically analysed and interpreted in relation to the research questions and theoretical frameworks.

4.4.2. Pattern Matching

Cortis and Muir (2022) outline 12 tips for reliably conducting pattern matching suggesting foremost that a literature review should be conducted to define theoretical patterns represented by the case study’s propositions. In the current investigation relevant literature is reviewed in the introduction of this chapter identifying theoretical patterns that inform propositions. The proposed theoretical patterns relating to two separate frameworks are:

1) Evidence of misunderstanding is followed by mediated learning experiences which results in a change in understanding or structural cognitive modifiability (Feuerstein et al., 2002; Tzuriel, 2013).

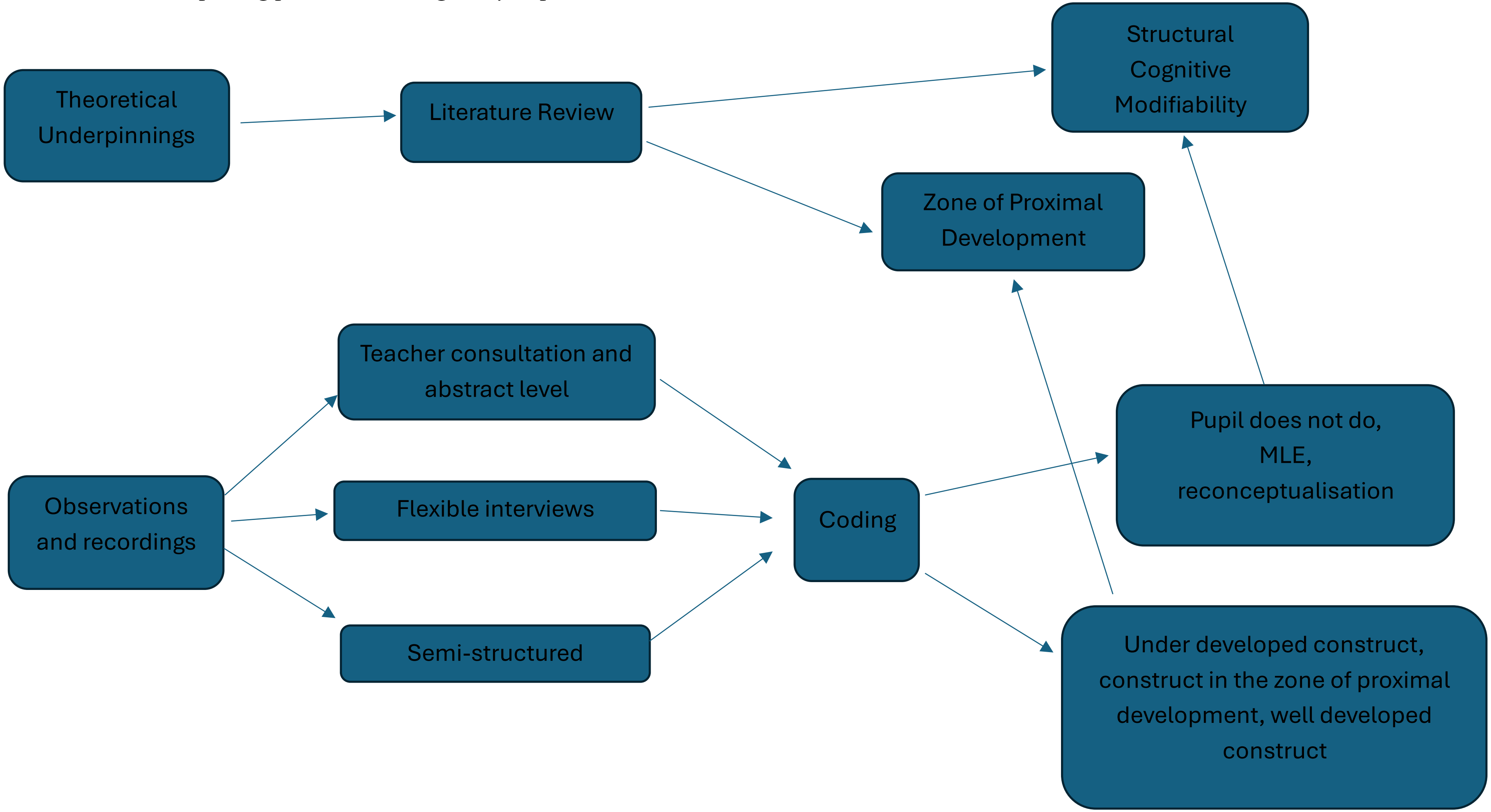
2) Dynamic assessment uncovers elements of tasks that a child can complete independently, elements they can complete with help, and elements they can complete either independently or with help (Vygotsky & Cole, 1978).

The theory of structural cognitive modifiability therefore predicts a pattern consisting of three coordinated elements: evidence of misunderstanding, followed by mediated learning experience(s), followed by a new conceptualization or understanding (Tzuriel, 2013). Pattern matching analysis in the current exploration looks for patterns in the empirical data consistent with that predicted by this theory.

Patterns consistent with the zone of proximal development (Vygotsky & Cole, 1978), were also represented in three different codes. First was evidence that the student exhibited behaviour to suggest a domain general or specific construct was well developed and this construct could be applied independently. Second, was evidence that the student exhibited behaviour to suggest a construct was developing, and this may be observed by the student displaying understanding or competency with a degree of support from the examiner. The final code was related to the student displaying behaviour to suggest a domain general or specific construct may be less developed despite scaffolding and support from the examiner. Figure 4 displays a visual flow chart of the pattern matching analytic process.

Figure 4

Flow chart depicting pattern matching analytic process.



4.5. Reliability

A number of measures were taken to improve the reliability of the design and analysis consistent with recommendations proposed by Yin (2009). The author endorses the use of multiple case studies which is adopted here. Also emphasised is the importance of the collection of multiple types of data from multiple sources to allow for triangulation. This is consistent with a post-positivist philosophical framework (Rogers & Willig, 2017). The reliability of the coding procedure was improved by the development of codebooks with definitions, elaborations and examples of themes or elements of patterns outlined. The development of codebooks helps standardise the coding process and is pivotal to improving reliability (Guest et al., 2012). Codebooks for themes related to mediated learning experiences, structural cognitive modifiability and the zone of proximal development can be seen at Appendices 23, 24 and 25 respectively.

An inter-coder reliability analysis was conducted with a second coder reviewing codes identified from the pilot data. This analysis suggested agreement between coders ranged from 64% to 100%. See Table 11 for an overview. A full detailed overview of the intercoder reliability analysis is available at Appendix 26.

Table 11

Percentage agreement between coders for each theme related to mediated learning experiences for the pilot data set

Theme (mediated learning experience)	Number of codes identified by principal researcher	Number of codes agreed with by second coder	Percentage agreement
Challenging	7	6	86%
Encouraging	11	11	100%
Engaging	3	2	67%
Explaining	19	16	84%
Explicit helping	8	5	63%
Making sense	6	6	100%
Monitoring	18	18	100%
Planning	8	7	88%
Scaffolding	14	12	86%
Self-regulation	8	7	88%
Sharing	9	8	89%
Verbalising	14	12	86%

4.6. Validity

Validity refers to the defensibility of assertions made by an investigation and comprises of elements such as content, construct, internal and external validity (Guest et al., 2012). Content validity is strengthened in the current case by the broad interpretation of dynamic assessment used with both the theories of ZoPD and SCM underlying theoretical propositions. Construct validity of the implementation of dynamic assessment is strengthened by the use of valid checklists used to code mediated learning experiences and learning functions from the data (Lauchlan, 2012). The validity of the dynamic assessment procedure is also strengthened by the experience of the researcher who had previously attended two separate practical training days on dynamic assessment. The researcher also had experience in conducting similar assessments while working in an educational psychology service. This experience goes towards meeting the standards required to conduct such sessions set and agreed by those in the field (Green, 2015).

While external validity is often considered to be high in case study research, internal validity can consequentially be problematic due to the large number of uncontrolled variables. Measures to increase internal validity in the current study as proposed by Yin (2009) are to use pattern matching and address alternative theories. Alternative explanations for each theoretical proposition are listed below in Table 12. Threats to validity related to protocol are addressed above in relation to construct validity. Researcher bias is negated by the use of a second coder to review data analysis. Data and excerpts supportive of the null hypotheses are identified and openly addressed in the findings section, with the implications of these discussed at length in the discussion and critical review and impact statement.

Table 12

Alternative explanations for each theoretical proposition

Theoretical proposition	Null hypothesis	Researcher bias	Threats to validity related to protocol
1) MDA will illustrate reconceptualisation of maths concepts that follows a mediated learning experience consistent with the theory of SCM.	MDA will **not** show that reconceptualisation of maths concepts follows a mediated learning experience	The researcher selectively reports or interprets data as evidence that MDA illustrates reconceptualisation of maths concepts following mediated learning experience	e.g. mediated learning experiences are not constructed or identified accurately, evidence of structural cognitive modifiability is not identified accurately
2) MDA will result in a change in domain general constructs that follows a mediated learning experience consistent with the theory of SCM.	MDA will **not** result in a change in domain general constructs that follows a mediated learning experience	The researcher selectively reports or interprets data as evidence that MDA illustrates changes in domain general constructs following mediated learning experience	e.g. mediated learning experiences are not constructed or identified accurately, evidence of structural cognitive modifiability is not identified accurately
3) The MDA procedure will illustrate domain general constructs (affective and cognitive) that are under-developed, well developed and in the zone of proximal development.	MDA will **not** illustrate domain general constructs (affective and cognitive) that are under-developed, well developed and in the zone of proximal development.	The researcher selectively reports or interprets data as evidence MDA illustrates domain general constructs that are under-developed, well developed and in the zone of proximal development.	Dynamic assessment procedures are not implemented with fidelity, Examples of developing constructs are not identified accurately
4) The MDA procedure will illustrate domain specific (maths) constructs that are under-developed, well developed and in the zone of proximal development	MDA will **not** illustrate domain specific (maths) constructs that are under-developed, well developed and in the zone of proximal development	The researcher selectively reports or interprets data as evidence MDA illustrates domain general constructs that are under-developed, well developed and in the zone of proximal development.	Dynamic assessment procedures are not implemented with fidelity, Examples of developing constructs are not identified accurately
5) MDA will provide practical information to teachers in relation to the student informed by theories of ZoPD and SCM.	MDA will **not** provide practical information to the teacher in relation to the student informed by theories of ZoPD and SCM.	The researcher selectively reports or interprets data as evidence that MDA provides practical information to the teachers in relation to the student informed by theories of ZoPD and SCM.	

4.7. Pilot Case

The pilot case was undertaken to inform the logistical procedures and data analysis. The case was carried out in accordance with the procedure outlined, informed by the Special Education Support Service framework for mathematics dynamic assessment. From conducting the pilot case it was found that no changes were needed with regards to the case study protocol or procedure.

4.7.1. Implications for Design

The pilot case did inform design changes within the study. The pilot case revealed that teachers were poorly placed to answer questions relating to how the dynamic assessment procedure supported the student. This was because the teachers had not observed the dynamic assessment sessions and had only received brief feedback from the researcher. As part of the original design teachers were to triangulate evidence in relation to observed links between mediated leaning experiences and improvements in learning functions but this was not possible due to teachers being unable to observe sessions.

Therefore, the focus of the semi-structured interviews with teachers in the proceeding cases was to determine whether they gained any practical advice from the feedback that they could use and then to determine to what extent they perceived the dynamic assessment procedure as being able to support the student in the Irish primary school context. These changes are reflected in semi-structured interview schedules at Appendix 19.

4.7.2. Implications for Analysis

A full analysis of pilot data was carried out. This included a thematic analysis of learning principles and mediated learning experiences apparent within the videoed flexible interview sessions as well as those identified by the pupil in their semi-structured interview.

This analysis was subject to the intercoder reliability evaluation detailed in the previous section which informed updates to codebooks and review of identified codes for the ensuing two cases. Full thematic analysis of learning functions and mediated learning experiences and pattern matching addressing the five theoretical propositions can be seen at Appendices 27-29.

Thematic analysis of teachers' responses in relation to queries of how they perceived the mathematics dynamic assessment as being able to support the needs of the pupils revealed three key themes. Namely, these themes were that the amount of contact time with the student requires consideration, school staff should observe the dynamic assessment, and the results of the assessment should be to produce practical recommendations for school staff. These themes were used to shape a deductive analysis of teachers' responses for cases 1 and 2. Full analysis of teacher responses in relation to proposition five can be seen at Appendix 29.

4.8. Ethical Considerations

This project was granted ethical approval by the Mary Immaculate Research Ethics Committee. Security was ensured by storing data securely in a password protected folder on a private laptop. All original video data and audio recordings were deleted following transcription. Anonymity and confidentiality were ensured by use of pseudonyms in the transcription of data and labelling of materials produced. Pseudonyms are used in the description of case study data below.

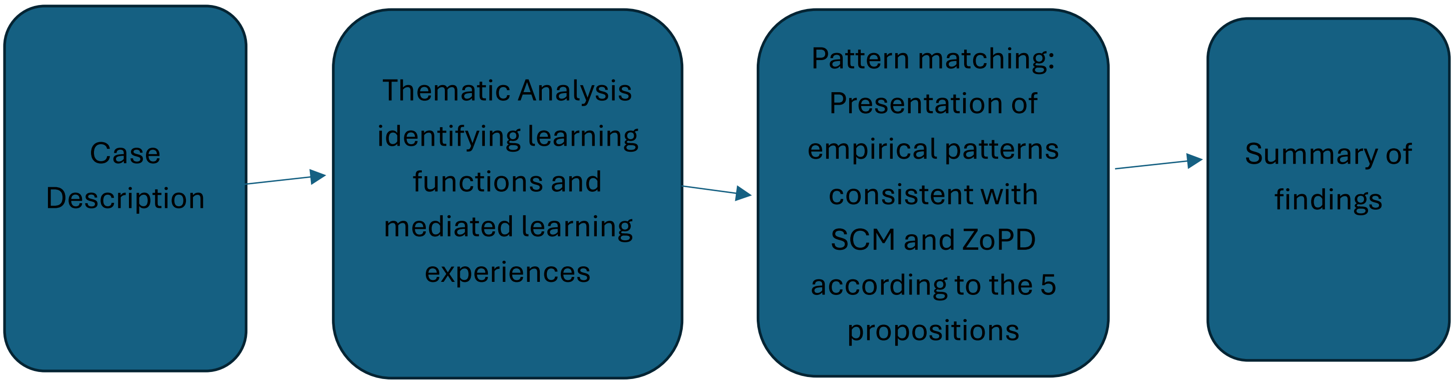
4.9. Findings

This section documents findings from the previously outlined research process. Findings from the two cases are outlined individually, followed by the presentation of a cross-case synthesis and discussion.

The findings in each case are outlined in the order as follows: First, a general case description is offered. Then a thematic analysis is described. This analysis aims to identify the nature and frequencies of learning functions and mediated learning experiences relevant for each case study and a thematic map is generated outlining these relevant themes. Findings are then outlined according to each of the five propositions. Pattern matching analysis is used to identify patterns within the data set consistent with the theories of SCM and ZoPD. For full thematic analysis and pattern matching protocols see Appendices 27-29, (Pilot data), 30-32, (Case 1) and 33-35, (Case 2). An outline of the structure for presenting findings for each case is depicted below in Figure 5.

Figure 5

Outline of structure for presenting findings for each case



4.9.1 Case 1: Louise

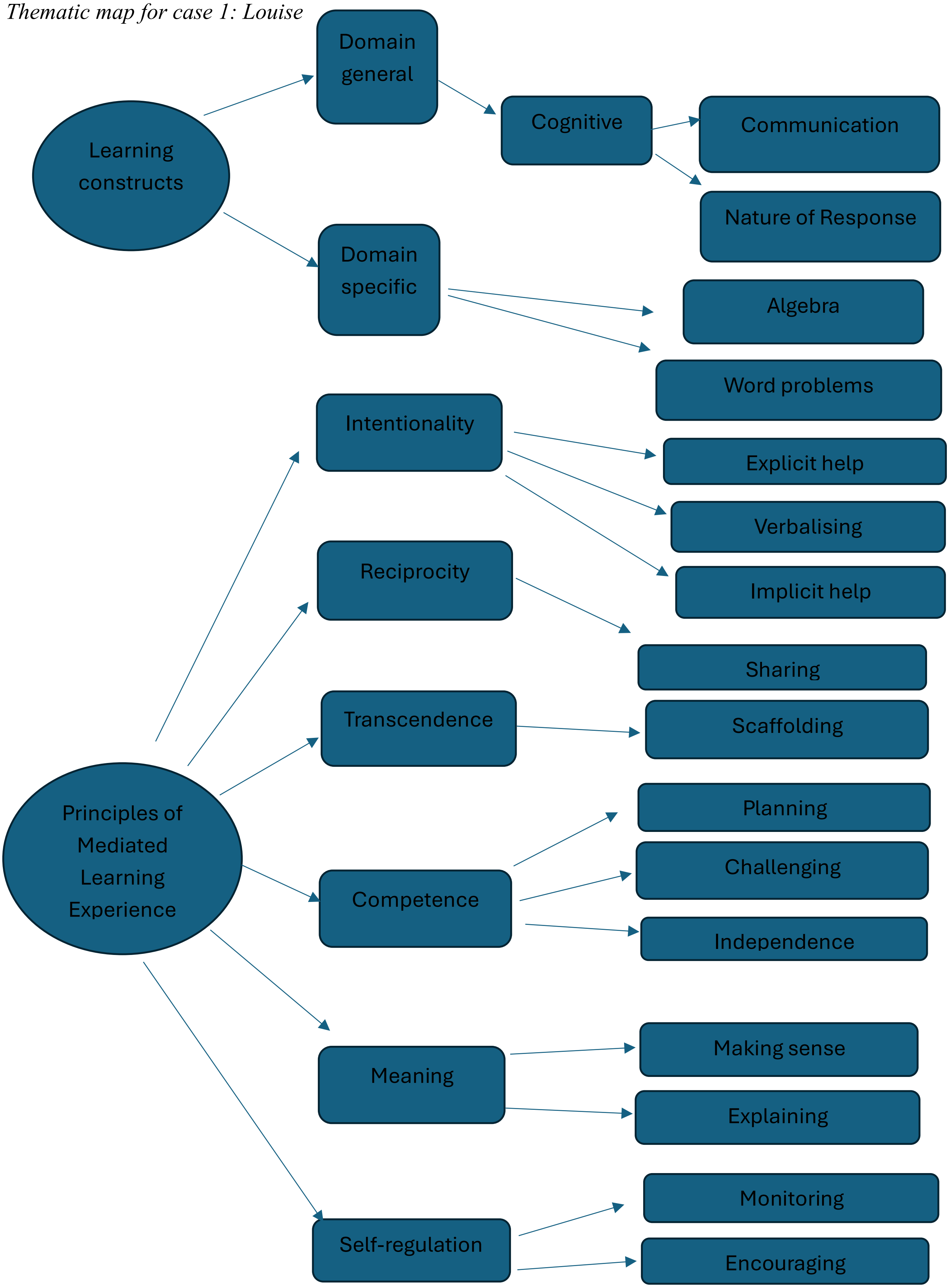
Louise is an 11-year-old girl attending 5th class in a mainstream primary school in a rural area. Louise is in a multi-grade classroom in a small two teacher school. Her class teacher suggests that Louise is a well-mannered and pleasant pupil. She is very sporty and likes playing basketball outside at break time. She also loves singing and music. Louise has difficulties accessing some aspects of the curriculum in general. The class teacher suggests she interacts well with other students and staff.

Ms. Mullins, the special education teacher, suggests Louise has had difficulties with mathematics since beginning school. Louise is currently having difficulty with a number of strands of the mathematics curriculum including number and place value, shape space and data, algebra, time and word problems. The class teacher notes they spend a lot of time on tables in class and that Louise is gaining fluency with them. Despite this the work is differentiated for her and she would not expect to do the same mathematics work as the rest of fifth class. Louise has daily withdrawal for mathematics support with the SET.

4.9.1.1. Thematic Analysis and Thematic Map. A thematic analysis was conducted to explore what themes were recurring within the data related to the MDA. The deductive thematic analysis was informed by learning functions and mediated learning experience checklists from the Dynamic Assessment UK website (*DA Learning Resources*, n.d.) as well as mathematical concepts outlined in the new primary maths curriculum (NCCA, 2023). Figure 6 outlines a thematic map for case 1 data detailing the relevant learning functions and mediated learning experiences identified.

Figure 6

Thematic map for case 1: Louise



Thematic analysis identified a number of relevant learning functions pertaining to Louise's maths attainment. No domain general affective factors were identified as relevant in this data set as Louise was perceived to be adequately motivated and well-regulated throughout the flexible interviews. Domain general cognitive learning functions identified included *Communication* and *Nature of response*. Communication refers to the ability *to communicate answers in a clear and coherent manner* (for definitions of learning constructs see Appendix 21). Communication was identified as a relevant domain for analysis in the current investigation by a number of sources including teacher consultation and flexible interviews. The flexible interview sessions consisted of frequent lengthy pauses in response to invitations to verbalise strategies or provide explanations.

Nature of response is defined as *the ability to answer with meaning rather than guess randomly* (See checklist at Appendix 21 for definitions). Louise frequently responded using guessing and trial and error particularly in response to word problems which were an identified area for development for her. Louise may respond with any number from the word problem as when asked "if each bag holds 16 apples, how many bags are required to hold 16 apples?" she replied with 16.

Relevant domain specific mathematical concepts identified in the current case were "algebra" and "word problems". These concepts were identified as areas for development for Louise through multiple sources including teacher consultation, error pattern analysis and flexible interviews. Full coding of all learning functions is available at Appendix 30.

Twelve components of mediated learning experiences (MLEs) consistent with the Dynamic Assessment UK checklist were identified in the data related to the interactions between the primary researcher and Louise. The most frequently observed of these were "explaining", "encouraging", "explicit help", "making sense" and "scaffolding". Overall, 102 codes related to MLEs were identified within the data set. Of note, Louise herself during semi-structured interview identified two themes that she found helpful. First, she suggested that the examiner helping her to make sense of word problems by using the whiteboard to draw out pertinent aspects of the task was very helpful to develop competency in this area. Secondly, she noted that generally receiving help to complete tasks was beneficial which may be interpreted as referring to scaffolding or offering explicit help. Frequencies of each theme or characteristic of mediated learning experiences is reported below in Table 13. Full coding of MLEs is available at Appendix 31.

Table 13

Frequencies of observed characteristics of mediated learning experiences in case 1 data

Theme	Frequency
Challenging	3
Encouraging	12
Explaining	16
Explicit help	4
Implicit Help	11
Independence	4
Making sense	17
Monitoring	2
Planning	3
Scaffolding	10
Sharing	4
Verbalising	16

4.9.1.2. Proposition 1: MDA will enhance domain general learning functions following the implementation of mediated learning experiences consistent with the theory of SCM.. An example of an empirical pattern within the data consistent with the theory of SCM was observed in relation to the domain general learning function "communication". Louise was not observed to effectively communicate her reasoning or thinking processes initially and this is consistent with reports from teacher consultation that suggests she has difficulty in this domain.

Mediated learning experiences that were intentional in attempting to improve communication were plentiful. Prompts to verbalise strategies or explain answers were numerous and this was recognised by Louise in her SSI as she suggested she found it hard to explain her maths and prefers to "just do it". Following these interactions Louise showed greater willingness and ability to communicate her mathematical reasoning. An example of this empirical pattern is outlined below at Table 14. Full pattern matching analysis for this learning function is available at Appendix 32.

Table 14

Example of empirical data consistent with a pattern of structural cognitive modifiability, (Feuerstein, 1991) for case 1.

Inability/Misconception	**Mediated Learning Experience**	**Structural cognitive modifiability**
S: Okay, next one. (1,3,7,13,_,_,_) *pause* What do you think? I wonder would the number line be able to help you? How would you be able to use that to figure this one out? *Pause* (**Flexible interview 1: line 254)**	L: There's two in the difference. S: There's two in the difference each time? Okay, so what's the difference between one and three? L: Two. S: And then between three and six? L: Three. S: And then between six and ten? L: Four. S: Okay, so you have two, three, four. So what's going on there? **Scaffolding (Flexible interview 1: line 200**)	*Context: a-b=2 is written on whiteboard* S: Can you tell me anything about A there? Is there anything that A can be and anything that A can't be? L: A can be one or two. **(flexible interview 1: line 784)**

4.9.1.3. Proposition 2: MDA will Illustrate Reconceptualisation of Maths Concepts that Follows Mediated Learning Experiences, Consistent with the Theory of SCM.

Thematic analysis identified domain specific learning functions related to algebra and number as areas for development for Louise. Pertinent to this proposition, structural cognitive modifiability was observed in relation to the strand algebra and the concept:

"articulate, represent and solve mathematical situations through the use of expressions and equations that include letter-symbols." (NCCA, 2023)

Triangulated data from error pattern analysis and flexible interviews suggested Louise had difficulty representing word problems with equations and solving them. Following relevant mediated learning experiences Louise developed competency and autonomy in completing these kinds of tasks. Word problems were made meaningful to Louise by allowing her to draw on the whiteboard and incorporating her interests, i.e. sports. One word problem posed to Louise was “one team scored three goals and three points, the other team only scored goals, but we don’t know how many, the match ended in a draw, what did the other team score?” (for context this was referring to a Gaelic football score where a goal is worth three and a point is worth one). Louise represented the problem with the equation 3x3+3=12 before correctly responding that the other team scored 4 goals. This was achieved independently without the need for any prompting or scaffolding. An example of the pattern observed within the data consistent with that suggestive of structural cognitive modifiability is outlined at Table 15 below with full analysis available at Appendix 32.

Table 15

Example of empirical data consistent with a pattern of structural cognitive modifiability, (Feuerstein, 1991) for case 1.

Inability/misconception	**Mediated learning experience**	**Structural cognitive modifiability**
Louise had some difficulty in completing equations. For more basic equations she was able to complete them accurately however for the majority she was unable to try. This will be explored in the flexible interview. **(error pattern analysis)**	*Context: a-b=2 is written on whiteboard* S: So, can A be one? L: No. S: Because it's too small, isn't it? Because we have to take something away to get to two, don't we? L: It could be three. S: Oh yeah, absolutely. And if it was three, what would B be? L: one. S: Exactly. Great job. So, what can A not be? L: Two. Or one S: well, What if it was two? Say if it was two, what would B be? L: zero. S: Yeah, so it can be two. But what can it not be? L: one. S: Exactly. L: Or zero. S: Zero, correct. **Scaffolding (Flexible interview 1: line 803)**	S: This time, the first team scored three goals and three points. The other team scored only goals, but we don't know how many. The match ended up in a draw. How many goals did the other team score? L: (writes 3x3+3=12) The other team scored four goals. **(flexible interview 2: line 1540)**

4.9.1.4. Proposition 3: The MDA procedure will illustrate domain general constructs (affective and cognitive) that are under-developed, well developed and in the zone of proximal development. The MDA procedure provided evidence of empirical patterns consistent with the ZoPD for the domain general cognitive learning function *nature of response*. There is evidence that Louise can use a trial-and-error approach to responding which lacks reason. There were a number of pieces of evidence from the transcript coded to suggest that Louise did not answer meaningfully in response to queries but instead echoed back information from word problems. Another pertinent example is when Louise was asked to create a number sequence for the researcher to decipher and listed three numbers in two successive turns but was unsure of the relationship between the three numbers when asked.

However, the identified pattern also confirms that with support and providing meaning to the tasks presented to Louise, she can systematically apply logic and procedures to complete maths tasks. An example of the observed pattern in the data is presented below at Table 16 with full coding available at Appendix 32.

Table 16

Example of empirical data consistent with the theoretical pattern of the zone of proximal development (Vygotsky & Cole, 1978) for case 1.

Does not do	Does with help	Does Independently
S: So. if the question was different, and it said each bag has 16 apples, how many bags could you fill with just 16 apples? What would the answer be? L: 16. S: So it would just be. so, 16 apples, and each bag has 16 apples. So how many bags would you be able to fill with 16 apples? L: two **(Flexible interview)**	S: So, say for example, okay, how many players are on a football team? Do you know how many players are on your football team when you play? L: Thirteen. S: Thirteen, okay, good. (takes whiteboard) So, if we have 13 players on a football team, (writes 13 on the whiteboard) and what would we do if we had 26 players who showed up to training? How many teams would we be able to put out? (writes 26 at the top of the whiteboard) *Pause* So, would we have enough for one team? L: Yeah. S: Yeah, you're absolutely spot on, we would. Now, would we have enough for two teams? So, we have 13 on this team, (writes 13) but we have 26 that are coming to train. L: Yeah. S: Yeah, so we'd have another 13 over here, wouldn't we? (writes another 13) Fantastic. So, we'd have enough for two teams. Would we have enough for three teams? L: *shakes head* **(Flexible interview)**	This time, the first team scored three goals and three points. The other team scored only goals, but we don't know how many. The match ended up in a draw. How many goals did the other team score? L: (writes 3x3+3=12) *Pause* The other team scored four goals. **(Flexible interview)**

4.9.1.5. Proposition 4: The MDA procedure will illustrate domain specific (maths) constructs that are under-developed, well developed and in the zone of proximal development. Evidence from the MDA procedure suggests that Louise's understanding of patterns and relationships can be considered to be in the zone of proximal development. Louise showed an ability to independently solve sequences with fixed intervals consistent with reports from the teacher consultation that repetition of times tables has aided Louise. The initial abstract level assessment suggested Louise had some difficulty completing other number sequences. She appeared to be reliant on a counting strategy and she suggested she uses counting to determine the next element of number sequences. This caused difficulty particularly when the difference between elements wasn't constant. Some sequences were observed to be too difficult to complete at this stage. An example of this pattern within the data is displayed below at Table 17.

Table 17

Example of empirical data consistent with the theoretical pattern of the zone of proximal development (Vygotsky & Cole, 1978) for case 1.

Does not do	Does with help	Does Independently
S: Fantastic. What about this next one? (1,4,9,16,_,_,_) (L got this one wrong and wrote 24,33,43) L: Threes. **(Flexible interview)**	S: What about our next one down here? (1,4,10,19,_,_,_) (L got this one wrong and wrote 30,42,53) Can you see them okay? L: *nods* *pause* L: Three. *pause* S: The difference is three in the first one. Is that what you mean? Ok what about the next one? L: *pause* S: You can use this to help if you like (hands number square) you can have the tens and units there if you like. L: Six. S: Yeah, six is the next one. L: Nine. S: Okay, so what's happening? L: going up in Three. **(Flexible interview)**	S: So, just for this one, you might be able to explain it to me because you got so many of them right. But what was the did you do with this one? (8,16,24,32,_,_,_,) (L got this correct and wrote 40, 48, 56) L: Eights **(Flexible interview)**

4.9.1.6. Proposition 5: MDA will provide practical information to the teacher in relation to the student informed by theories of ZoPD and SCM. Pattern matching was employed to analyse teacher semi-structured interview data to determine whether the maths dynamic assessment procedure improved the understanding of the teacher in relation to the pupil's learning functions informed by the theories of the zone of proximal development and structural cognitive modifiability.

Responses from the class teacher during the semi-structured interview suggests that the maths dynamic assessment procedure did improve her understanding of the student in relation to learning functions identified. The teacher suggested that information relayed in feedback regarding maths vocabulary was useful in relation to helping Louise comprehend word problems and also highlighted the use of whiteboards to help Louise visualise and make sense of word problems. Table 18 lists key quotes that link the teacher's understanding to identified constructs within the zone of proximal development. Here the teacher indicates that using the whiteboard in class is a strategy that will be implemented going forward and with repetition Louise may be able to internalise this process.

Table 18

Key quote linking teacher's understanding to identified constructs within the zone of proximal development.

Teacher Key quote
Teacher: .. I suppose it was great, you know, you mentioned about the maths vocabulary, so that's really interesting to see, … now you mentioned again about the visualisation, so that's again another great bit of advice there to know, and I will definitely use, because you were saying the whiteboards worked well, so to leave the whiteboards there available to use whenever maybe, and as you said like, you know, drawing out the things for Louise first so that she can visualise it then, you know, after plenty of repetitiveness with her, in that it might eventually, she may be able to visualise it herself, so that could be a strategy going forward to use, so yeah, no look, it was great to get some more information on it and more feedback on her.

Thematic analysis was conducted to explore themes in the teacher's semi-structured interviews related to their perceptions of the maths dynamic assessment process. This analysis was informed by the data from the pilot study that identified three themes relating to the above. Both the class teacher and SET highlighted the importance of gaining practical recommendations as a result of the assessment and suggest psychologists may conduct an assessment and leave the teacher without a sense that they are adequately informed or supported. Both teacher and SET outlined the importance of a member of staff observing the assessment process to gain relevant insights and both staff members communicated a wish for the dynamic assessment sessions to be extended to include more visits. Key quotes under the identified themes are listed at Table 19 below.

Table 19

Key quotes under identified themes for teacher SSI

Theme	**Quote: Class teacher**	**Quote: special education teacher**
Teachers' expectations related to support from external agencies for maths difficulties	T: Yeah, there are a lot of difficulties, definitely, I suppose, you know, like, people come in, they do an assessment on a child, you know, they tell you what needs a child has, but then often it's, okay, you know, here's their needs, off you go now and figure it out yourself, and that happens a lot of times, that we need more support in that sense	T: Well, how can they help us best support that pupil? Because we'll have tried as much as we can within our setting. So that's really, I suppose, that's why we reach out to anybody.
Length of contact time with student	T: Well, I suppose like the length of time you can give is obviously another difficulty, so like, you know, what can you really bring to a child in two, three sessions really, you know, it's very hard for them, you know, if you ask me have I noticed any difference, any changes let's say, or if I noticed any progression with Louise, I'd say it's very hard in two or three sessions to make a massive impact, so that may be going forward, it would have to be over a longer period of time, you know	T: Yeah, no, it's definitely beneficial. But I mean, coming in three times, it's probably not enough. You have to build relationships as well, but definitely any help that NEPS or whoever could offer a school would be welcomed. But it would be maybe better if it was more structured for a longer period, like an intervention of six weeks or whatever.
Teachers to be involved/observe	Maybe even actually, so we'll say, you know how you would have taken out a child and done a little bit of work, it might be a benefit for a class teacher to even go in and observe what you're doing, so we'll say you might have some sort of strategy that works well for the child that I can bring into my teaching	Well, this would be a good strategy to use, you know, because obviously you were here and you were working away, but we have just the report to see what you were doing, you know, so, you know, if we even could shadow you maybe for a while or something like that.

4.9.1.7. Summary. This case provided the following evidence in response to the defined research question. The maths dynamic assessment process helped identify learning functions which are central to Louise's maths attainment including communication and giving meaningful responses. The two domain specific areas of focus for this assessment procedure were algebra and word problems. Characteristics of mediated learning experiences most commonly identified from the interactions between Louise and the researcher included making sense of the concepts and encouraging verbalising of thought processes. Incorporating Louise's interests particularly sports, to make the concepts meaningful was also particularly beneficial. Louise gained benefit from drawing the concepts from word sentences which supported her thinking.

Pattern matching analysis suggested Louise developed skills in communicating her answers more coherently as a result of the dynamic assessment. Louise also developed skills in being able to determine relevant information from word problems and represent this using an equation. Further to this, the dynamic assessment procedure helped to identify that Louise is developing skills in being systematic in her approach to maths problems. Louise can at times provide trial and error answers but with support such as scaffolding and providing relevant supplementary materials such as number squares, Louise can be more systematic in her approach to maths problems.

Responses from the class teacher suggest the dynamic assessment procedure provided useful information to her in relation to Louise's learning functions related to maths. Allowing Louise to use the whiteboard to provide meaning for word problems is an identified mediated learning experience which will be adopted in the classroom moving forward. Of note, despite garnering useful recommendations from the MDA process, the class teacher recognised that she has not observed notable improvements in Louise's maths attainment in the classroom.

These observations are inconsistent with the analysis identifying evidence of structural cognitive modifiability and are discussed in more detail in the cross-case synthesis and discussion with relevance to the validity of the current investigation.

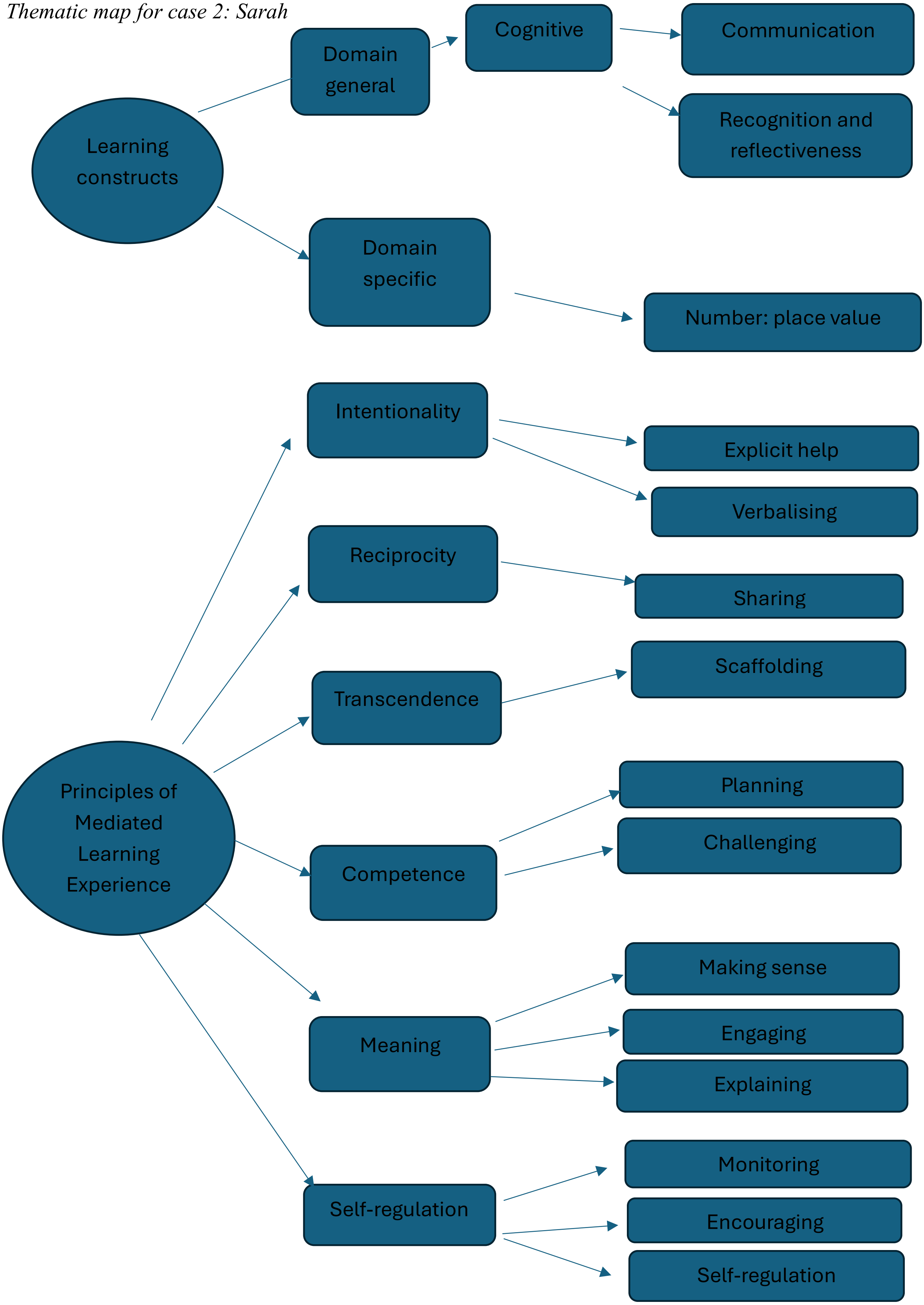
4.9.2. Case 2: Sarah

Sarah is an eight-year-old girl attending second class in a small mainstream primary school in a rural area. She is part of a two-teacher school with multi-grade classes. Miss Beirne, the class teacher, suggests that Sarah is a very kind, warm and sensitive girl. Sarah is currently having difficulties with multiple strands of the mathematics curriculum. The class teacher suggests she has difficulty with numeracy, understanding of place value and is developing competency with some procedures such as addition in columns. Notably, some difficulty may be apparent with multi-step problems. Conversely Sarah is more competent with some strands such as shape and space.

4.9.2.1. Thematic Analysis and Outline of Thematic Map. A thematic analysis was conducted to explore what themes were recurring within the data related to the maths dynamic assessment for the second case. This followed an identical procedure to case 1. Figure 7 outlines a thematic map for case 2 data detailing the relevant learning functions and mediated learning experiences identified.

Figure 7

Thematic map for case 2: Sarah



The MDA procedure elucidated a number of important learning functions relevant to Sarah's maths attainment. As was the case in the first case study, no domain general affective factors were identified as Sarah appeared to be motivated and had no difficulties in regulating herself and attending to tasks. Pertinent cognitive factors identified were *Recognition and reflectiveness* and *Communication*. As was evident in the first case, communication was identified as a core learning function for Sarah. When asked to explain her thinking Sarah would often reply that she didn't know how she came to an answer. Developing Sarah's communication was the focus of extensive mediation as alluded to in subsequent sections.

Recognition and reflectiveness refers to the ability of the pupil *to recognise when they are wrong and reflect on their answers* (for definitions of learning constructs see Appendix 21). Sarah appeared to be careless at times in relation to labelling of concrete materials. Although she showed some understanding of the concept of place value she often made mistakes of switching tens and units. She was generally unaware of these mistakes even when encouraged to reflect.

The domain specific learning function which was the focus of the majority of flexible interview sessions was place value. Triangulated evidence from teacher consultation and flexible interview identified this as an area for development for Sarah. Full coding for identified learning functions is available at Appendix 33.

Thematic analysis identified 84 instances of mediated learning experiences in total between the researcher and Sarah. These instances covered 10 types of mediated learning experiences. Most frequent characteristics observed were *verbalising, scaffolding, making sense, encouraging* and *monitoring*.

For example, Scaffolding was used to model a systematic way to use concrete materials to complete operations. An analogy of going to the shop to swap ten units for a ten rod in concrete materials was offered to help Sarah gain more of an understanding of place value and this was coded under “making sense”. Strategies to help Sarah monitor her responses were frequently used such as the primary researcher verbalising what Sarah had done and why she did it to allow her to check for errors. Prompts to verbalise strategies were frequently used to allow Sarah to structure her thinking in relation to tasks and engage in a collaborative exchange. Sarah noted this was difficult for her and during her semi-structured interview suggested it made things more challenging. Frequencies of codes under mediated learning experience themes is documented at Table 20. Full coding for all themes of MLEs is available at Appendix 34.

Table 20

Frequencies of mediated learning experience themes identified in case 2 data.

Theme	Frequency
Encouraging	9
Explaining	10
Explicit help	1
independence	2
Making sense	17
Monitoring	7
Planning	2
Scaffolding	15
Sharing	4
Verbalising	17

4.9.2.2. Proposition 1: MDA will enhance domain general learning functions following the implementation of mediated learning experiences consistent with the theory of SCM. Analysis of the data arising from the MDA procedure implicated an empirical pattern consistent with SCM related to the identified learning function recognition and reflectiveness. Sarah often followed a procedure when completing tasks using concrete materials such as tens and units, but often made mistakes such as counting tens as units or vice versa. Sarah did not show an awareness of these mistakes at any stage during flexible interview one. For example, when adding 18 and 13 in a column she did not recognise a mistake in addition on the unit's side despite being asked if it was correct.

Following mediation, towards the end of flexible interview two, Sarah was completing a two-digit addition task of 14+17. She wrote 11 in the unit's column and then corrected herself without instruction. This represents an improvement in reflectiveness and awareness. This pattern of improvement reflective of structural cognitive modifiability is detailed below at Table 21. Full pattern matching analysis is available at Appendix 35.

Table 21

Example of empirical data consistent with a pattern of structural cognitive modifiability, (Feuerstein, 1991) for case 2.

Inability/Misconception	Mediated Learning experience	Structural cognitive modifiability
S: Okay. This time, can you do that for me? *writes 14+18* So, you have to be the explainer, and can you tell me all about what your plan is here? Sarah: So, I'm getting 4 tens **(flexible interview 1: line 287)**	S: Okay. Which number is which? Can you show me which number is which down here? Sarah: This one is twelve (one ten and 2 units) and this one is thirteen (3 tens and one unit). S: Okay, fantastic. So, this one is twelve because you have one ten and two units, right? Sarah: Yeah. *starts making a change to the other pile and puts one ten and 3 units* **Monitoring (Flexible interview 2: line 848**)	S: Okay, show me. Sarah: *counting on fingers* *Writes 11 down in units' section, does not carry the 1 S: 11, okay, so you, oh, Sarah: *corrects herself and writes one and carries the one* S: okay, so you do 11, and what do you do then with the 1? Terrific, great job. **(flexible interview 2: line 990)**

4.9.2.3. Proposition 2: MDA will Illustrate Reconceptualization of Maths Concepts that Follows Mediated Learning Experiences, Consistent with the Theory of SCM.

Triangulated data suggested Sarah exhibited difficulties in grasping concepts related to place value. Sarah showed inconsistency in her approach to counting or assigning a value to a mix of concrete tens and units. Sarah was observed at times counting the units individually and then continuing to count assigning the tens a value of one. She could also count each individual block on the tens rod.

Mediated learning experiences focused on developing skills in this area included encouraging Sarah to verbalise the process to help her to be systematic and monitor her labelling and procedure as well as an emphasis placed on monitoring. A task focused on recognising and counting tens was then completed with Sarah in which she showed an ability to count in tens. The meaning and generalisability of this task was explained by suggesting she wouldn’t have to count each block in the tens rod but could count in tens instead.

Sarah then showed an ability to apply this skill in the next task to count the tens as a result of the addition operation as opposed to counting individual blocks or assigning an incorrect value. This pattern consistent with the theory of SCM can be seen below at Table 22.

Table 22

Example of empirical data consistent with a pattern of structural cognitive modifiability (Feuerstein, 1991) for case 2.

Does not do	**Relevant Mediated Learning Experiences**	**Structural Cognitive Modifiability**
S: And then we have 10 *referring to the first 10s rod*. So what's 12 plus 10 Sarah: *counts on from 12 pointing to each block of the 10s rod* 21 **(Flexible interview 1: line 147)**	S: And we have 2 sets of 10, I've got 2 sets of 2 of 10, and would you now, to add these up, Sarah, would you count up every single one? (pointing to each block of the tens rod) Sarah: No. S: so how would you do it? Sarah: Just by knowing all the 10s what it makes up **implicit help (Flexible interview 2: line 965**)	S: And so now that you've done that, the new number looks like this. (pointing to the 4 tens rods and one unit) So you have your one unit, you have your two tens, one ten, and another one ten. So what's your answer? Sarah: Twenty. forty S. Forty-one, isn't it? Fantastic. **(flexible interview 2: line 1429)**

4.9.2.4. Proposition 3: The MDA procedure will illustrate domain general constructs (affective and cognitive) that are under-developed, well developed and in the zone of proximal development. Sarah was able to independently describe the procedure she was using to perform addition using concrete materials despite this showing a developing sense of number. For example, she suggested she makes two piles, "scrambles them" together and counts them up. There were many instances identified where Sarah did not communicate her answers or processes in a clear and coherent fashion. On occasions when Sarah was asked about how she knew she could represent numbers in different ways with the concrete materials she often replied "I don't know". With help Sarah was able to expand on her answers in a collaborative exchange with the researcher. This pattern is consistent with the theory of the zone of proximal development as outlined below at Table 23.

Table 23

Example of empirical data consistent with the theoretical pattern of the zone of proximal development (Vygotsky & Cole, 1978) for case 2.

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Does not do	Does with help	Does independently
Sarah: yeah *writes 13* S: Wow, well done, you got that spot on, well done. How did you know that you could show it to me like this? *Referring to one 10 rod and 3 units* Sarah: I don't know. **(Flexible interview)**	S: Good job. Now what's our next job?. Sarah: to get, to count up the other number S: Good job. What's our other number called? Sarah: 18 S: Can you show me that? How many tens are in 18, Sarah: One. S: Perfect. Well done. And how many units? Sarah: Eight. **(Flexible interview**)	S: 11! Well done. Can you tell me how you figured that out? Sarah: I just grabbed, I just got some fives and six, and I put them all together **(Flexible interview)**

4.9.2.5. Proposition 4: The MDA procedure will illustrate domain specific (maths) constructs that are under-developed, well developed and in the zone of proximal development. The dynamic assessment data suggests that Sarah is developing her concept of number. Sarah can independently use a counting strategy to do addition, however she does this using a count all strategy which is inefficient. With help from the researcher Sarah shows she can be more efficient with her addition strategy by showing an awareness of place value and counting in tens with concrete materials. Sarah finds it difficult to complete addition with regrouping using the concrete materials and this is beyond her level of ability at this time. This pattern is consistent with that predicted by the zone of proximal development. An example of this pattern is displayed below at Table 24.

Table 24

Example of empirical data consistent with the theoretical pattern of the zone of proximal development (Vygotsky & Cole, 1978) for case 2.

Does not do	Does with help	Does Independently
Researcher: I think you missed one there, so I think it's eleven. So well done. Okay, so we have eleven. So then we wrote down our one. And when we have eleven, do we have enough to go to the shop to swap it for a big ten? Sarah: No. Researcher: Oh, we don't? Okay, so how many do we need to go to the shop to swap for a big ten? Sarah: Eighteen. **(Flexible interview)**	Researcher: Sarah, have a look at this. Can you count in tens for me, Are you able to count in tens? Sarah: Yeah. Ten, twenty, thirty, forty, fifty, sixty, seventy, eighteen, nineteen, ninety, a hundred. Researcher: Wow, that's exactly right. Well done. So, you can count up in tens. Sarah: Yes **(Flexible interview)**	So, let's look at this one. *writes 5+6* Sarah: *counts out 5 units, then counts out 6 units in separate piles* I'm done Researcher: Okay, what's the answer? Sarah: *counts each unit in both piles* 11! **(Flexible interview)**

4.9.2.6. Proposition 5: MDA will provide practical information to the teacher in relation to the student informed by theories of ZoPD and SCM. Pattern matching was employed to analyse teacher semi-structured interview data to determine whether the maths dynamic assessment procedure improved the understanding of the teacher in relation to the child's learning functions consistent with the theories of the zone of proximal development and structural cognitive modifiability. Data in this case provides evidence to suggest that teacher understanding was not improved as a result of the dynamic assessment procedure. The teacher indicated that the recommendations were not beyond what she was already implementing, and she had a feeling that she still did not know exactly what the issues are. Table 25 below outlines key quotes related the class teacher's understanding.

Table 25

Key quotes related to the class teacher's understanding of the student following MDA procedures.

Teacher Key Quote
Researcher: With that, and again, just finishing up, do you feel that some of the recommendations might be useful moving forwards in terms of some of the observations that were made? Or do you find that they're not consistent with maybe what you were seeing in the classroom? T: No, they sound exactly like what I'm seeing. And yeah, I suppose, um, I got nothing, nothing I didn't see already. And, but maybe there's nothing else to see. T: And just, yeah, I suppose, I suppose I still have a feeling that I don't know what the specific issues are, but that's maybe just part of the whole, that's where we're at.

Thematic analysis was conducted in relation to the class teacher's semi-structured interview data to identify data relevant to the themes identified in the pilot data. This class teacher suggested her expectations for input from external agencies would be to receive very specific support related to strategies to be implemented within the classroom. Under the theme “contact time” she also communicated the wish for the sessions to be more frequent.

Key quotes related to identified themes are listed below at Table 26.

Table 26

Key quotes related to identified themes for teacher semi-structured interview.

Theme	Quote
Expectations for support from external agencies	S: And what would your expectation be? T: So, if a psychologist was to come in, for example? Well, that they would give you specific recommendations that you could give in the class.
Contact time	T: So, somebody that comes in and works one-to-one over a course of time is definitely going to know that child like we do. And we'd be able to share those ideas. And I think obviously something longer term, but I don't know how that would work out timewise financially.

4.9.2.7. Summary. In summary data from this case addresses the research question of "how can maths dynamic assessment support a student exhibiting maths difficulties in the Irish primary school context?". The empirical data matches predicted patterns proposed by theories of structural cognitive modifiability and the zone of proximal development. In Sarah's instance this was the case in relation to developing her awareness and recognition of mistakes. Domain specific factors that were relevant were in relation to place value. Mediated learning experiences employed to support Sarah were plentiful, however prompts to verbalise strategies were not effective and according to Sarah, these slowed her down. To accommodate for this the researcher often verbalised Sarah's strategies for her which improved her recognition and reflectiveness.

Sarah is continuing to develop her communication skills and her understanding of number. Sarah's class teacher reported that she did not gain practical recommendations or an explanation of the presenting issues as a result of the dynamic assessment that was beyond her current level of understanding. The class teacher re-emphasised a need for input from external service to provide practical recommendations.

4.9.3. Cross-case synthesis and Discussion

A cross-case synthesis is employed here to analyse and compare data from the two cases in relation to the identified theoretical propositions. Subsequently, a synthesis of relevant data from these cases is used to assess the extent to which the current study addresses the overarching research question and what conclusions may be drawn from this analysis. Common findings and discrepancies across the separate case study data are analysed with reference to reliability of findings. A comprehensive discussion of findings is carried out with reference to key literature and arguments within the field.

4.9.3.1. Thematic Analysis of Learning Functions. Thematic analysis identified three cognitive learning functions across the two cases pertinent to the maths dynamic assessment process. Affective learning functions, while identified as relevant in pilot data were not recognised across the two outlined cases. A common cognitive learning function identified was *Communication*, while *Nature of Response,* and *Recognition and Reflectiveness* were recognised to be pertinent functions for Louise and Sarah respectively. This narrow range speaks to the centrality of the functions identified in developing competencies in mathematics. The identification of *Communication* as the constant core learning function across the two cases is consistent with the emphasis placed on being a good communicator in maths which is a key competency listed under the new curriculum (NCCA, 2023). Moreover, *Nature of response* and *Recognition and reflectiveness* are learning functions that are key to promoting autonomous learning. In their implementation of dynamic procedures at a classroom level based on Feuerstein's learning functions, Popa & Pauc (2015) recognised the importance of encouraging monitoring and reflection to produce autonomous learners in mathematics. These functions are subsumed under the key competency of "Being an active learner" in the new curriculum (NCCA, 2023). These findings further highlight the congruency between this approach to assessment and national policy.

Domain specific constructs identified were also similar across cases relating to the strands number and algebra with a focus on elements of place value, word problems, patterns and relationships, and equations. These concepts represent a narrow range of focus across these cases. Indeed, a common theme may be extracted from these elements which is flexibility in understanding of number or "number sense" (Dehaene, 2001). For example, evident throughout Louise's flexible interviews was her reliance on learned strategies such as counting or memorisation of tables to complete number sequences. These strategies were ineffective and led to difficulties with sequences comprising of variable intervals between elements. Likewise, when presented with a numerical sequence increasing by 11 each time, Louise was less intuitive in identifying this as she rigidly attempted to calculate the difference between elements using a counting strategy each time. Flexibility in understanding and use of number may have resulted in her using a splitting strategy to identify an addition of one ten and one unit each time (e.g. see Peltenburg et al., 2010).

Flexibility with understanding of number arises from the developmental stages outlined in the context and policy background section including intuitively tracking and comparing quantities, oral counting, relating quantities to Arabic numerical symbols and the formation of a number line with spatial encoding (Von Aster & Shalev, 2007). A deficit in the development of these numerical abilities can lead to an over reliance on counting strategies (Geary, 2011). In both cases and pilot data obtained, there were clear observations that the pupils were implementing learned procedures without conceptual understanding. Interestingly, this is a pertinent finding in the only other qualitative examination of a maths dynamic assessment process conducted by Moscardini & Moscardini, (2020) with their case study Lara. While a need is recognised for both procedural fluency and conceptual understanding as part of developing mathematical proficiency (Dunphy et al., 2014), the current approach to assessment may offer a valuable avenue to identify those with a deficit in the latter competency.

4.9.3.2. Mediated Learning Experiences. Thematic analysis identified 13 various characteristics of mediated learning experiences identified in interactions between the researcher and pupils. The most common characteristics identified were encouraging the pupil to verbalise strategies, promoting meaningfulness of the task, encouraging monitoring of answers, providing scaffolding, and providing enthusiastic praise as feedback. Significantly, in the first case study Louise explicitly referred to some of these characteristics as being central to improving her understanding in her semi-structured interview. These characteristics included *making sense* and *explicit help/scaffolding.* The use of the whiteboard to draw pertinent task information as well as utilising examples incorporating Louise's special interests aided in this regard. While Louise had difficulty with completing word problems incorporating estimation and division with concepts such as the number of passengers per bus or the number of apples placed in a bag, she was much more engaged when the same mathematical problem was portrayed as the number of players on a football team. Engaging Louise in this way allowed her to develop mathematical competencies.

Using the whiteboard and incorporating interests was coded under the theme *making sense* as defined by the Dynamic Assessment UK checklist (*DA Learning Resources*, n.d.). This theme relates to the concept of transcendence as originally defined by Feuerstein which is the propensity to apply learning attained to novel situations (Feuerstein et al., 1991). Recalling that the purpose of mediated learning experiences are for the learner to internalise the relevant psychological tools to modify their own cognitive structures, the benefit of the two flexible interview sessions for Louise may be realised if she internalises this process to use independently in future to increase her propensity to learn (Feuerstein et al., 1991). The finding of relevance of this characteristic of mediated learning experience in the case of Louise is echoed by Popa & Pauc (2015) who also discerned this type of mediation can improve performance in mathematics at a whole class level. Louise's recognition of this theme during her semi-structured interview gives reliability to this finding.

Conversely, Sarah suggested during her semi-structured interview that prompts to verbalise her strategies were not helpful and slowed her down. An array of other characteristics of mediated learning experiences were identified through observation, however, none were identified as significant by Sarah. It should be noted that Sarah offered little reflective analysis of the MDA process during her semi-structured interview. Sarah's resistance to verbalising of strategies may be interpreted in a number of ways. This may be reflective of her reliance on trial and error as an approach to task completion or a reliance on procedural learning without conceptual understanding. The feedback that mediated learning experiences were slowing her down may be interpreted as the beginning of a process of internalisation of a systematic approach to problem solving. It should be noted this interpretation is purely speculative but is congruent with the theory of SCM (Feuerstein et al., 1991). Conversely, this feedback from Sarah may be related to poor quality of mediation and task structuring for her on the part of the researcher, or perhaps evidence consistent with the null hypothesis related to the theory of SCM.

4.9.3.3. Structural Cognitive Modifiability. The cross-case analysis reveals observed patterns within the data that is consistent with the theory of structural cognitive modifiability (Feuerstein et al., 1988). The current investigation incorporated multiple components of this theory consistent with the theoretical pattern. Recalling an overview of this theory from the literature review at the beginning of the chapter, the theory proposes that a child's propensity to learn can be increased through mediated learning experiences which modify cognitive structures and are internalised to allow self-mediation of learning (Feuerstein et al., 1991).

The evidence for Louise exhibiting this pattern relates to her inability or unwillingness to communicate thought processes or answers to questions during the initial phases of the flexible interviews with the researcher. This can be seen by the frequent coding of long pauses in the flexible interview transcription. Louise would also use single words in response to presented numerical sequences such as "threes" to denote a sequence rising in threes. The communication that "A can be one or two" in response to a presented equation with unknown variables represents an improvement in this regard that could be interpreted as the result of internalised mediated interactions including frequent invitations to verbalise responses and scaffolding.

Improved modifiability may also be observed in the pattern of initial impulsive, reactionary responding that lacked systematic processing at the beginning of the initial flexible interview, followed by more thorough independent processing at the end of the second flexible interview session. This modifiability led to improved performance in representing word problems with equations and solving them. Louise often echoed values embedded within the question when responding initially; however, by the end of the second flexible interview she showed an ability to discern salient aspects of a word problem, represent them with a numerical equation and solve for the answer. This is despite clear difficulties in the areas of word problems and equations being observed through multiple sources prior to and during the flexible interviews. This evidence is consistent with the tenets of the theory of SCM that implicate the quality of mediation in giving a learner the tools to learn (Lauchlan & Daly, 2023), and promoting the independent application of these tools to achieve culturally dependent knowledge and skills (Feuerstein et al., 1991).

Potential improvement owing to the dynamic assessment process was less marked in the case of Sarah. This is acknowledged through a recognition from her class teacher that she has not seen an improvement in learning and Sarah's own report of the dynamic assessment procedure which was inconclusive. Slower progress may represent evidence to support the null hypothesis, or that dynamic assessment does not result in changes in domain general and domain specific functions. Equally, the lack of progress may be seen to be attributed to individual differences in modifiability seen to be a proximal factor for development (Tzuriel, 2013). This raises queries in relation to the researcher's ability to effectively mediate as well as the necessary amount of contact time needed on average to produce meaningful change or develop the propensity of the learner to learn from direct contact with the environment (Tzuriel, 2013). In relation to this point it is of interest to note that the total frequency of mediated learning experiences coded in analysis for Louise was much higher (102) than for Sarah (84).Actively searching for and openly reporting data that is not consistent with patterns predicted by the theories of the ZoPD and SCM is an important step in improving the validity of qualitative research as acknowledged by Yin (2009) and Cortis and Muir (2022). This discussion is further signposted in the critical review and impact statement chapter in section 5.3.1 that refers to validity.

Although the suggestions of an absence of improvements in modifiability or propensity to learn are reported, improvements were observed and coded by the researcher. Improvements in Sarah's ability to recognise mistakes and be reflective were recorded as well as evidence of development in understanding of place value. Sarah appeared to internalise prompts to check her answers and explain her reasoning which allowed her to become more reflective and monitor her answers. This led to her correcting a mistake without intervention from the researcher towards the end of the second flexible interview. Sarah also showed an ability to transfer learning of counting in tens to completing two-digit addition tasks. Previously during these tasks, she counted each block of a tens rod or conversely assigned the tens block a value of one when completing the task.

Recalling that due to a small sample size, the aim of this qualitative exploration is to assess analytical generalisation as opposed to statistical generalisation; the interpretation of the data is with a view to inferring whether the observations are consistent with the theoretical blueprints that describe what happens in the dynamic interaction between examiner and student. Taken together, the improvements across cases align with the theoretical framework of structural cognitive modifiability lending tentative support to the proposition that mediated learning experiences can be internalised and result in modifying of deficient cognitive processes for young people (Feuerstein et al., 1991). The data therefore adds to literature in the area that documents the specific importance of the quality of the interaction between the student and teacher or child and parent in fostering learning and development (Tzuriel, 2013; Tzuriel & Remer, 2018; Tzuriel, 1996).

4.9.3.4. Teacher Understanding of the Pupil's maths conceptualisations. Data from teachers' reports offered mixed results in relation to theoretical propositions. One teacher reported positive feedback in relation to the maths dynamic assessment in that they gained practical advice and strategies from the process which they plan to implement with the student in the classroom. For the second case study the teacher suggested the recommendations were not new and they had not seen dramatic improvements in relation to the student's maths attainment. A caveat to this suggestion however is that it was explained that the class are currently engaged with a strand of the curriculum different to that which was the focus of the dynamic assessment. Depending on the interpretation, these disparate findings call into question the utility of dynamic assessment as an approach that bridges the gap between assessment and intervention (Lidz & Haywood, 2014).

In their semi-structured interviews, all teachers made reference to the need for input from external services to provide practical advice and resources to support the student. Teachers made reference to the importance of school staff being involved in the assessment in an active role or in observation. This theme links to the emphasis on practical recommendations stemming from the process as the teachers may have been able to observe useful strategies for themselves in session if they were present. All teachers also made reference to one of the positive factors of the dynamic assessment process being the amount of contact time spent with the student by the researcher in comparison to the approach of administering a standardised assessment. Despite this, teachers expressed a desire for the contact time to be extended perhaps to five or six sessions.

These findings taken together point to a limitation of the current study which was the definition of the role of the teachers in the process. The issues with the role of the teacher in this investigation is that they did not observe the assessments, they potentially did not receive adequate feedback in relation to what was undertaken, and they potentially were not adequately informed in relation to the nature and goals of the process prior to the onset of the dynamic assessment. This is evident as there appeared to be a lack of clarity on the part of teachers related to whether the input was a form of assessment or intervention. The findings of the study offer support to recommendations made by Yeomans (2008), namely that it is important to address unfamiliarity with DA by teachers at the initial consultation stage; it is important to collaboratively agree on goals and set expectations for the input; follow up to assessment is crucial; and school staff should be involved in the DA process where possible.

4.9.3.5. Summary of Cross-case analysis and Discussion. The cross-case analysis and discussion have presented the empirical evidence obtained in response to the five outlined theoretical propositions with a view to answering the overarching research question. The evidence from the current study suggests that the implementation of a MDA process can help support a student exhibiting maths difficulties in a number of ways. The implementation of mediated learning experiences can result in the internalisation of these interactions and the improvement of deficient cognitive functions. In the current study these cognitive functions were communication, nature of response, and recognition and reflectiveness. The improvement of these functions improves the propensity of the pupil to learn. This is observed in improvements in understanding of equations, the concept of number and place value across the two case studies. Finally, there are mixed findings related to how the MDA process provides meaningful recommendations to teachers. A limitation of the design of the current study is the role of teachers as merely recipients of feedback related to the process. Increased collaboration with teachers is required for the successful implementation of a MDA consistent with findings from previous studies (Yeomans, 2008).

4.10. Chapter Conclusion

This chapter outlines the scope, design, methodology, analysis and findings of the empirical investigation. The literature review summarises the results of the systematic literature review undertaken as part of the previous chapter which outlines what is already known in the area of MDA in an educational context. The results of this systematic review implicate a gap in the literature to conduct a theoretically informed, qualitative analysis of a MDA procedure. Moreover, it was identified that Feuerstein's theory of SCM in so far as it focuses on developing a propensity to learn through internalisation of mediated learning experiences and improvement of deficient cognitive functions that approximate executive functions (Lauchlan & Daly, 2023), has not been incorporated into designs exploring DA in this domain. The research question for the current investigation therefore was "how can the implementation of a MDA procedure support a pupil exhibiting maths difficulties in the Irish primary school context?".

The current investigation involved a deductive analysis of interactions between the researcher and pupil informed by checklists that define these constructs (*DA Learning Resources*, n.d.). Findings from this investigation add to research that implicates mediated learning experiences as characteristics of interactions that improve the propensity of the pupil to learn. In the case of Louise in particular it was evident that she could implement skills autonomously to complete maths tasks that she did not exhibit prior to the flexible interview. A limitation of the current investigation is the role played by the class teacher and SET. Feedback from teachers during semi-structured interviews suggest that observation of the flexible interview sessions would be crucial to gaining practical recommendations from the process. It is also important to collaborate with teachers adequately prior to the onset of the process to explain the process and set expectations and goals. The ensuing critical review and impact statement chapter provides a more comprehensive critical analysis of the process undertaken here while discussing the potential implications of the current study.

5. Critical Review and Impact Statement

5.1 Overview.

The concluding chapter in this thesis serves as a platform for critical examination of the research, alongside an exploration of the potential implications of the implementation of maths dynamic assessment in Irish primary schools, within academic and applied fields. Each section draws attention to the strengths and limitations of the study. The critical review begins by reflecting on the choice of a post-positivist philosophical framework in section 5.2 and provides a rationale for its suitability given the subject matter and nature of the investigation. The implications for interpreting the findings of the research as a consequence of this choice are discussed with a comparative analysis provided.

Subsequently, section 5.3 provides a thorough justification for the selection of research design, measures, and analytical methods, accompanied by a critical evaluation of these decisions. This section reflects on the validity and reliability of the study.

The implications of this research offering are then evaluated in section 5.4. A discussion of how theoretical comprehension and knowledge are advanced as a result of this undertaking and where the research fits within the body of literature that addresses maths dynamic assessment in the educational domain is outlined. The relevance of the research findings and potential implications for professional practice in educational psychology and schools are then outlined in section 5.5 with respect to national policy and curriculum in Ireland. This is followed by potential directions for future research that attempts to build on the current investigation in section 5.6. This chapter concludes with an impact statement in section 5.7 that outlines succinctly the contribution of the research to the field and evidence of its originality.

5.2 Philosophical Paradigm.

A post-positivist philosophical paradigm was selected as the foundational framework for this thesis. Importantly, the choice of a philosophical paradigm implies assumptions related to three core elements; ontology, epistemology and methodology (Cresswell & Poth, 2018). The review of the choice of a post-positivist paradigm in the current context ascertains to what extent these elements are consistent with the research question and aims of the study.

Post-positivism presupposes the objective nature of reality which implores rigorous and systematic data collection, consistent with a positivist position (Maksimović & Evtimov, 2023). Conversely, post-positivism acknowledges the limitations of relying solely on a positivist stance for the uncovering of an objective truth, particularly with complex phenomena within the social sciences, and acknowledges the epistemological process is tainted by biases associated with the researcher (Clark, 1998; Maksimović & Evtimov, 2023). The strength of employing a post-positivist paradigm in the current study is it allows for greater flexibility in the implementation of qualitative measures to identify and describe the complex theoretical phenomena that underlie this approach (Pryce et al., 2014.).

In order to measure complex phenomena, post-positivism embraces multiple worldviews. In attempting to gather data from multiple sources however, a post-positivist stance strives to be objective by acknowledging the individual bias in each report. In essence, "the existence of multiple worldviews does not extend into a belief in complete relativism and an incommensurability of perspectives" (Pryce et al., 2014 p. 84). Thus post-positivism supports the collection of multiple sources of evidence but emphasises the need for triangulation of data sources to identify constructs that are assumed to approximate objectivity (Creswell & Poth, 2018; Rogers & Willig, 2017).

The current investigation employs case study methodology (Yin, 2009) with qualitative analysis in addressing the research question. This methodology is consistent with post-positivist assumptions using a deductive form of analysis informed by the theories of the zone of proximal development (Vygotsky & Cole, 1978) and structural cognitive modifiability (Feuerstein et al., 1991). The use of a theoretical interpretive framework within case study methodology is promoted by Yin (2009) to focus the investigation on relevant variables and is consistent with post-positivism. The collection of multiple forms of qualitative data, triangulation of data, and the use of interrater reliability in coding are suggestive of congruency between methodology, epistemology and ontology under the assumptions of post-positivism (Cresswell & Poth, 2018). As a further strength, these design and data collection methods allowed for the identification of relevant mediated learning experiences that were linked to improved outcomes by the students themselves which gives the findings depth and validity.

The adoption of a positivist position would have informed a different methodology and has been employed previously in studies in this area identified in the systematic review (e.g. Wang, 2014; Wu et al., 2017). The limitations of adopting a positivist approach in this domain are numerous and include the following:

- An objective measurement of domain general and specific outcome variables would involve the reduction of complex phenomena (Clark, 1998) such as reconceptualisations and evidence of modifiability to gains made on measures between pre and post assessment. Such measurements may not adequately measure the results of the dynamic assessment procedure.
- Measurement of mediated learning experiences solely through tools such as *The Observation of Mediation Interaction Scale* (Tzuriel & Remer, 2018) to assess the relationship between this concept and structural cognitive modifiability would deny the validity of multiple worldviews and so would discount the voice of

the student in identifying what approaches they perceived as being most helpful to them.

- There are practical and logistical issues related to the quantitative exploration of the research question including recruiting enough participants for group comparison and measurement of fidelity of administration across multiple sessions with each participant.

Equally, on the other end of the ontological scale a relativist philosophical paradigm may have been employed to explore the research question. Within a relativist framework, emphasis would have been placed on the importance of understanding the participants' subjective meanings and interpretations of dynamic assessment which aligns with assuming futility in attempting to comment on an objective reality (Cresswell & Poth, 2018). The result of such an approach would be a rich description of the dynamic assessment experience as perceived by the (Creswell & Poth, 2018). However, in contrast to positivist and post-positivist stances such a framework would be limited in relation to the interpretation and generalisability of findings.

Therefore the adoption of a post-positivist philosophical framework results in limitations with regards to the generalisability of findings in comparison to a positivist stance and provides less rich descriptive detail than a relativist paradigm (Cresswell & Poth, 2018). However, a post-positivist stance prioritises objectivity and empirical evidence, seeking to establish causal relationships for constructs which are too complex for experimental or survey data (Yin, 2009). The philosophical framework is determined to be appropriate in the current exploration to assess an individualised approach to dynamic assessment. A post-positivist philosophical framework allowed for flexibility in the design of the study to ensure that rich data from a number of sources could be gathered. This was coupled with rigorous and systematic data analysis to determine evidence that approximates objectivity.

5.3. Research Method, Design and Procedure

As a detailed comparative analysis of the philosophical framework employed is provided in section 5.2, this and subsequent sections of the critical review assess the strengths and limitations of methodological factors within this framework. The Special Education Support Service (SESS) framework for maths dynamic assessment provided a structure for the procedure of the investigation to follow. The framework outlines a protocol that emphasises the layering and interaction of assessment and intervention which is in contrast to the discrete stages between a pre and post-test in a “sandwich” approach (Daneshfar & Moharami, 2018; Lidz, 1995). The steps defined by the framework are with an aim to determine the skills or cognitive constructs that need to be developed and so the framework is individualised and process focused (Haywood, 2012). This chosen approach shows consistency with the aims of the project and the philosophical framework adopted as it allows for flexibility and adaptability in the interactions between the researcher and the student to explore maths conceptualisations.

Despite this consistency there are apparent points for critique in relation to study design. The adapted role of the class teacher and special education teacher (SET) in the procedure and within the overall design is one such point alluded to in the empirical chapter. As a result of logistical issues preventing teachers from observing the dynamic assessment, the role of the class and special education teachers appeared merely symbolic or nominal. Teacher semi-structured interview (SSI) data which is a second-hand reflection of the researcher’s report of the procedure is artificial rather than consisting of authentic observations and evaluations of the process. This issue in design represents a lost opportunity for teachers to triangulate observations that linked particular mediated learning experiences (MLE) to improvements in understanding, should they have been apparent. This limitation in design was identified by teachers during their semi-structured interviews with a common theme identified across the three cases that teachers should have some involvement in the process either by observing, watching the videos of the interactions, or taking part in the assessment. This also has relevance for the implications of the study.

Following the pilot case report, teacher SSI schedules were adjusted with the aim to determine whether the process resulted in an improved understanding of the child's maths conceptualisations and to what extent the dynamic assessment procedure would meet the needs of the school. Teacher and SET reflections therefore were affected directly by the time allocated by the researcher in explaining the procedure in the initial consultation and during feedback. These processes were insufficient to adequately inform teachers of the theory underlying dynamic assessment and the aims of the process which is recognised as being of central importance when conducting dynamic assessment within schools (Yeomans, 2008). This is reflective of a larger time constraint issue in the management of the process as a whole.

The time constraints inherent in this project significantly impacted various aspects of the research process. The meticulous planning required for dynamic assessment sessions, coupled with the need to provide written and oral feedback, proved particularly time-consuming. Moreover, conducting a comprehensive pilot case study to refine the research design necessitated additional time allocation. Transcribing video files and semi-structured interviews, along with conducting extensive thematic analyses, were further compounded by the limited time available, underscoring the challenges posed by time constraints on the overall project's execution. Overall, the scope of the project potentially warranted both further resources and an adjusted time frame to improve methodological rigour.

5.3.1. Validity

A critical analysis of the research design and methodology must include a comment on reliability and validity, which are parameters typically defined in quantitative terms.

Despite this, Guest et al. (2012), in a chapter addressing these concerns suggests a modification to the definition of validity which is embraced here. The authors cite terminology quoted by Ian Dey that defines validity in a more inclusive way as an enquiry that is ‘sound,’ ‘defensible,’ and ‘well-grounded’.

The definition forwarded by Dey accounts broadly for what the authors refer to as “big V validity” which addresses the validity of the project as a whole and incorporates constituents, which are elements referred to as “little V validity”. These elements include face validity, content validity, construct validity, criterion validity, internal validity and external validity (Guest et al., 2012). Therefore, the current study is critiqued in relation to the degree to which the assertions that it makes may be considered sound, defensible and well-grounded with reference to these concepts.

Perhaps most pertinently, the assertion made by the research that the dynamic assessment process was valid must be critically analysed. This critical analysis relates to construct validity defined by Yin (2009, p.40) as “identifying correct operational measures for the concepts being studied”. Using appropriate measures adds defensibility to the assertions of the study. In the analysis of the validity of the dynamic assessment procedure the “correct operational measure” or instrument is the researcher. The defensibility of any assertions of the study, (e.g. dynamic assessment results in modifiability of learning principles) whether positive or negative (i.e. whether it does or does not) is dependent on the degree to which the dynamic assessment was carried out with fidelity in accordance with the essence of what dynamic assessment is or is purported to be.

Green and Birch (2019) offer the most exhaustive guidelines for effective dynamic assessment practice as a result of a collaboration with five experts and fifteen additional practitioners. The experience of the researcher is seen to meet some of the essential criteria listed such as the necessity of having an undergraduate degree. There is a lack of consensus related to the required number of days of training ranging from 1-15 which the researcher's experience falls within. The report also identifies 23 criteria and skills that are specific to and essential for effective dynamic assessment practice. These criteria relate to knowledge and applied skills in four areas:

1) dynamic assessment and its theoretical underpinnings

2) the learner and theories of learning

3) mediation

4) the task or task analysis

Reflecting on these criteria, knowledge of the four key areas for dynamic assessment had been acquired on the part of the researcher through attendance at dynamic assessment training and the comprehensive researching of theoretical underpinnings for purposes such as writing of research proposals. However, skills in these areas are only acquired through practice and repetition. This aspect of the researcher's experience warrants careful consideration when interpreting the study's findings. The primary researcher, being a trainee with relatively limited applied practice in implementing dynamic assessment in practice settings, may inadvertently underestimate the effectiveness of dynamic assessment in improving mathematical understanding and providing practical recommendations. Results supporting the null hypothesis for example may suggest that the dynamic assessment process does not result in relevant improvements, or may portray the researcher's inability to mediate effectively (Lidz, 1991).

The content validity of the maths dynamic assessment session - that is the extent to which an assessment or measurement tool are reflective of the entire range of content it is purported to measure (Rogers & Willig, 2017) - is strengthened by the incorporation of both of the two main theoretical frameworks that underpin dynamic assessment i.e. the zone of proximal development (Vygotsky & Cole, 1978) and structural cognitive modifiability (Feuerstein et al., 1991). The use of Dynamic Assessment UK checklists that informed the assessment process and the analysis with extensive examples of 14 characteristics of mediated learning experiences identified within the data further strengthens the content validity of the investigation.

Internal validity concerns the degree to which any observed outcomes in an investigation can be attributed to the intervention rather than to alternative explanations (Rogers & Willig, 2017). . Yin (2009) proposes that internal validity in the case of explanatory case studies deal with inferences in relation to causal relationships. the nature of which in the current study is the relationship between mediated learning experiences and modifiability. Making such inferences in the current study presents certain challenges. In the trade-off between ecological and internal validity, field research such as was conducted in this instance is skewed towards an ecologically valid protocol that challenges claims of internal validity due to limited control over extraneous variables.

Using pattern matching and addressing rival theories gives strength to causal inferences made in the current study as suggested by Yin (2009), however the extent to which rival theories are accounted for is a point of critical analysis. Yin (2009) documents multiple theories which are threats to internal validity which may be of relevance. Some rival theories can be considered to be adequately accounted for in this investigation. For example, a focus on accurate reporting of data consistent with the null hypothesis was particularly evident in case 2. Due consideration was also given to direct rival theories. For example, the likelihood of the alternative theory that in-class teaching may have accounted for observed improvements was reduced through study design elements and was considered to be less threatening to internal validity due to the persistent, pervasive difficulties in maths reported as inclusion criteria for each of the three cases as well as the short timeframe the sessions were conducted across.

An implementation rival may have been relevant in the current case however, such as to say that perhaps the influence of the researcher in some way accounted for observed improvements which threatens inferences of a causal relationship between MLEs and modifiability. For example, it may have been the case that appointments with the researcher led to improved attendance of the pupil which may have been the causal factor in improved understanding of maths concepts.

To improve internal validity two measures may have been implemented. A theoretical replication may have been employed (Yin, 2009), which would have involved the recruitment of a further case with different input from the researcher to act as a comparison. Furthermore, divergent validity may have been assessed, which examines whether the intervention affects variables it should not theoretically influence. Employing measures of non-equivalent dependent variables, as recommended by Yin (2009), would have addressed this concern by gathering measurements of variables that the MDA should not have influenced. Employment of such an approach may have strengthened the assertion that improvements attributed to maths dynamic assessment were specific to mathematical abilities and not attributable to improvements in unrelated domains, such as spelling. Employing a theoretical replication and non-equivalent dependent variables within the design would have strengthened internal validity and adequately addressed the implementation rival.

5.3.2. Reliability

Reliability is a fundamental aspect of research, as a study cannot be valid if it is not reliable (Rogers & Willig, 2017). In the current study, reliability is bolstered by several methodological approaches. Firstly, the use of a case study protocol informed by the Special Education Support Service framework enhances the reliability of data collection and analysis.

This standardised protocol ensures consistency in data collection procedures across multiple cases, reducing the potential for inconsistencies in measurement or bias (Yin, 2009).

Intercoder reliability, a key aspect of ensuring the reliability of data analysis, was assessed in the study. A third-year member of the Doctorate in Educational and Child Psychology programme served as a second rater, and a comprehensive codebook was utilised to support the coding process. The agreement between raters on the consistency of codes with predefined definitions and the use of checklists supports the reliability of the data analysis.

However, a critical analysis reveals limitations in the intercoder reliability analysis. The assessment was conducted on only a portion of the data, rather than the entire dataset which is not consistent with best practice for ensuring intercoder reliability (Guest et al., 2012). Also, the consensus coding approach adopted limited the scope for the second rater to identify new codes within the data, potentially impacting the thoroughness of code identification. While this may have little implications for the identification of additional MLEs it does have relevance for the identification of empirical patterns within the data consistent with the theory of structural cognitive modifiability (Feuerstein et al., 1991). This is the case as the second rater may have agreed with the codes presented under these themes, but the inability for them to view the data in its entirety limits their ability to view excerpts within the data which may have been inconsistent with the theoretical pattern or invalidated some of the codes identified. Despite these limitations, the chosen approach was deemed the most feasible given the quantity and density of the data, as well as the time constraints of the project alluded to above.

Reliability of findings however is bolstered by triangulation of data from multiple sources, including objective scores on abstract level assessments, researcher observations, student feedback, and teacher perspectives. This triangulation enhances the credibility and reliability of the identified learning constructs and mediated learning experiences, providing a more robust foundation for the study's conclusions consistent with methods proposed by Yin (2009).

In conclusion, the critical analysis of the philosophical paradigm and methodology employed in this study underscores both strengths and limitations in its approach to investigating dynamic assessment in supporting children with math difficulties. By examining the alignment with theoretical frameworks, methodological rigour, and considerations of validity and reliability, this analysis provides valuable insights into the robustness and credibility of the study's findings. The subsequent sections of this critical review will delve into the implications of the study's findings for advancing understanding of the subject area, as well as how these findings may inform educational psychology practice.

5.4. The Implications of this Study for Research in this Area.

The current research adds to a broad and diverse body of literature with a focus on dynamic assessment. There are a number of distinct ways in which the current research makes a contribution to understanding within the subject area. This includes how the structure and design may be appropriate for investigation of an individualised approach to dynamic assessment and how similar methods may be employed to address central arguments in this subject area (section 5.4.1). The results of the research also lend themselves to support the theoretical underpinnings of dynamic assessment (section 5.4.2). Finally, the research contributes to the understanding of how dynamic assessment can be applied to curriculum-based measures and maths specifically (section 5.4.3). Each of these contributions are discussed.

5.4.1. Design of the Current Investigation

This research holds significant implications for the field of dynamic assessment because of its design and approach to answering the defined research question. The case study design utilised (Yin, 2009) allowed for the implementation of an idiographic or individualised approach which exemplifies the true essence of dynamic assessment (Haywood, 2012). While other research offerings have utilised a case study design in this domain, some studies have merely outlined case illustrations (e.g. Lidz & Gindis, 2003; Lidz & Peña, 1996), while others have utilised case study design with data analysis which is not interpretive but descriptive (Li, 2015; Moscardini & Moscardini, 2020). Moreover, other studies have used case study design and employed a quantitative analysis of improvement between pre and post-test (Hasson & Botting, 2010; Rahimi et al., 2015). Such an approach has limitations with regards inferences that can be drawn from statistical analyses on small sample sizes without a control group. There are also confounding factors such as the potential practice effects which may have contributed to changes in scores following mediation (Hasson & Botting, 2010).

The above-mentioned research designs represent the challenges faced in the efforts to empirically investigate the implementation of an individualised approach to dynamic assessment. Seminal author in the area of education and dynamic assessment Julian Elliott in 2003 called for the quantitative evaluation of interventions informed by dynamic assessment (Elliott, 2003), and 15 years later Elliot further emphasised the lack of methodologically rigorous studies in the analysis of the implications of dynamic assessment research (Elliott et al., 2018). The author re-emphasised the need for education to move away from a number of case illustrations as evidence of efficacy of this approach particularly in light of unverified claims in relation to the trainability of executive functions. The current study exemplifies a method of using an appropriate design that has sufficient methodological flexibility to effectively analyse the dynamic assessment procedure while negating the necessity to attempt to infer statistical generalisation. Research conducted in accordance with the current design marries methodological rigour and flexibility in assessing the implications of dynamic assessment.

5.4.2. Theoretical Foundations of Dynamic Assessment

This thesis contributes to the understanding of the theoretical foundations of dynamic assessment by providing empirical support for key theoretical propositions informed by the zone of proximal development (Vygotsky & Cole, 1978), and structural cognitive modifiability (Feuerstein et al., 1991). Through analytical generalisation, as outlined by Yin (2009), the study extrapolates findings from specific cases to support broader theoretical constructs. Patterns of empirical data in this study therefore align with the original observations and interpretation of Vygotsky in suggesting that there are things pupils can do independently and things they can do with appropriate support (Moll, 1990). Findings are also consistent with and therefore offer tentative support to the original theses of Reuven Feuerstein in identifying the importance of mediation of environmental stimuli to improve learning (Falik, 2019). The research therefore is consistent with the body of experimental research cited in the empirical chapter that suggests a relationship between the quality of mediation and resulting change to cognitive structures (Klein, 1991; Russell et al., 2008; Tzuriel & Shomron, 2018; Tzuriel, 1996).

The research also adds to the endorsement of the theoretical constructs alluded to and their applications. For example the research adds valuable insights to the growing body of literature advocating for the implementation of mediated learning experiences (MLEs) within educational settings (Fauziah Abdul Rahim et al., 2009; Popa & Pauc, 2015; Robinson-Zañartu et al., 2017). By examining the potential benefits of teachers incorporating this approach into their pedagogical practices, the study highlights the role of MLEs in facilitating cognitive development and promoting academic achievement among students. Furthermore, the research suggests MLEs, and dynamic assessment generally, may be useful to help identify barriers to learning by targeting deficient cognitive functions and providing targeted interventions to address these challenges (Haywood & Lidz, 2007). By recognising and targeting cognitive deficits through mediated interactions, teachers can create supportive learning environments that foster cognitive growth and adaptation.

A final theoretical component that data from this study addresses is the concept of improving the propensity of the learner to learn by targeting deficient core cognitive learning functions (Feuerstein et al., 1991; Lauchlan & Daly, 2023). This theoretical component suggests that by equipping students with the cognitive tools and strategies necessary to learn effectively from their environment, MLEs enhance the child's capacity to directly engage with and benefit from educational experiences (Tzuriel, 2013). This concept is contentious within the literature(Elliott et al., 2018) and is discussed further in the next section (5.4.3). Despite this, the data from the current study suggests that through mediation Louise's communication skills and Sarah's recognition and reflectiveness with respect to answers improved. In turn these developments appeared to improv the ability of the students to engage with the maths tasks. With the interpretation of this finding in mind, the current investigation is limited with regard to three variables.

First, the number of sessions needed to produce significant change requires further investigation and is not adequately addressed here. Indeed, some experimental data utilising approaches based of Feuerstein's methods evaluate year-long interventions with students (Tzuriel et al., 2021). The second variable draws attention to the lack of follow-up data in the current investigation to assess whether students' learning improvements are maintained over a longer period of time. Follow up data would assess the impact of the assessment process in providing the pupils with cognitive tools to continue to further reap benefit from their educational experience and this would add to the internal validity of the study. Finally, the current analysis consists only of two case studies of children in the Irish primary school context. Therefore, while some observations documented here are consistent with theoretical patterns such as the importance of quality of mediation to foster cognitive development and maths achievement, this is by no means conclusive, and findings should be interpreted cautiously.

5.4.3. Contribution to Literature in the Area of Curriculum Based Dynamic Assessment.

This research contributes to the discourse surrounding the application of dynamic assessment to curriculum-based measures and more specifically the relevance of dynamic assessment in the domain of mathematics. Research in the area of dynamic assessment broadly varies along a number of dimensions already alluded to, related to methods employed and views of the purpose of dynamic assessment. The focus of the dynamic assessment is a further important factor (Fuchs et al., 2008). The current research makes a contribution to the literature that relates to dynamic assessment in mathematics.

The research design allows for the research to comment on the potential benefit of targeting domain general and domain specific learning functions through focusing the dynamic assessment on curriculum-based measures. As alluded to in the previous section, (section 5.4.2) the concept that dynamic assessment can improve the propensity of the learner to learn is debated within the literature (Elliott et al., 2018). The core learning functions identified by Feuerstein that underlie this position approximately align with what are now referred to as executive functions (Lauchlan & Daly, 2023). To this end Elliott et al. (2018) draw a comparison between this approach and the failing of brain training to transfer gains made in the laboratory to real life settings. Thus, this conflict draws into question the utility of implementing domain general dynamic assessment tasks for the targeting and improvement of domain general learning functions to be transferred across settings.

There is a body of literature that asserts that learning potential as approximated through dynamic assessment is domain specific. Such studies have found DA of domain general cognitive constructs such as reasoning, memory, and verbal ability independently predict a very small amount of variance on maths outcomes when compared with the same static measures (Luković et al., 2022; Speece et al., 1990)However, DA of inductive, analogical reasoning and semantic memory for digits and abstracting numerical information from sentences was found to be a more significant predictor of maths outcomes (Stevenson et al., 2014; Swanson & Howard, 2005). Moreover, Stad et al. (2018)suggest that DA of inductive reasoning predicts unique variance on maths outcomes separate to cognitive flexibility as measured by the Iowa card sorting task. Finally, Cho and Compton (2015) found no relationship between learning potential for decoding and maths performance in 112 1st graders. Therefore, relevant literature suggests learning potential is a better predictor of performance when assessed relative to constructs closely related to the outcome as opposed to domain general constructs.

By assessing both domain general cognitive learning functions and domain specific maths concepts, the current thesis further contributes to this body of literature. The research design places a central focus on understanding how the modifiability of these constructs aids mathematics achievement. According to the theory of structural cognitive modifiability (Feuerstein et al., 1991) improvements in domain general cognitive functions facilitate more effective interactions with the environment, suggesting that enhancements in these areas underlie improvements in mathematical understanding (Tzuriel, 2013). The current study however clearly indicates that focusing on mathematics as the target domain can lead to improvements in both domain general and domain-specific learning constructs. Such findings provide support for the use of a maths dynamic assessment procedure for pupils exhibiting maths difficulties.

Most pertinently the current study adds to the literature that emphasises an individualised, process-oriented approach to dynamic assessment of maths. The only other study identified through a systematic review of the literature that utilises an idiographic, interactionist approach to dynamic assessment with a case study design is that of Moscardini and Moscardini (2020). Many similarities can be drawn between the current study and it. There are also both complimentary findings as well as discrepancies in method and analysis.

Consistent with findings from Moscardini & Moscardini (2020) the presentation of concepts using the concrete to abstract continuum was found to be central to dynamic assessment sessions across all three cases. Indeed, strategies to represent number bonds across this continuum were comparable between the eight-year-old case study "Lara" in the study documented by Moscardini and Moscardini (2020), and the pilot case "Peter" in the current investigation. Moreover, the flexible nature of the interaction between the researcher and the student resulted in a greater understanding of the strategies used by the student to complete presented tasks. In the case of Lara, it was found that she attempted to use procedures without conceptual understanding. Similarly, this was found in the case of Louise in the current study (case 1) who attempted to use a learned procedure of counting the difference between elements within a sequence of numbers. Louise encountered difficulties implementing this approach with variable differences between elements. Like in the case of Lara, this provided substantial evidence for procedural learning without conceptual understanding. This is an example of how a detailed understanding of the preferred processes of the student in maths can be obtained by utilising an individualised approach to dynamic assessment.

5.4.4. Summary of Implications of this study for Research in the area.

To conclude this section, the current thesis' distinct contribution to the field is acknowledged. The research adopts an individualized approach to dynamic assessment, but in contrast to the descriptive analysis conducted by Moscardini and Moscardini (2020), is guided by theoretical propositions, providing a focused and theoretically grounded exploration of dynamic assessment outcomes (Yin, 2009). Through systematic analysis, the research yields objective evidence of improvements in mathematics understanding following dynamic assessment sessions, tentatively supporting the implications of the role of mediated learning experiences in fostering these outcomes (Feuerstein et al., 1991; Tzuriel, 2013). This highlights the practical relevance and potential impact of dynamic assessment outcomes in informing tailored interventions and support strategies for students experiencing mathematics difficulties. Such observations bridge appropriately to the proceeding section which discusses the implications of the current research for professional practice.

5.5. Implications of the Study for Professional Practice in Educational Psychology, Schools.

The following section discusses the implications of the research in relation to its relevance for educational psychology practice and its potential for implementation within schools. The research findings provide valuable insights into the use of curriculum-based dynamic assessment within educational settings and raise important questions regarding its feasibility, form, and implementation. This discussion takes places in section 5.5.2. As has been alluded to throughout the study the application and purpose of dynamic assessment procedures vary extensively (Caffrey et al., 2008; Daneshfar & Moharami, 2018), which must be taken into consideration with reference to any discussion of the implications of these findings; and so a broad overview of the various dimensions and categorisations of dynamic assessment is provided first in section 5.5.1.

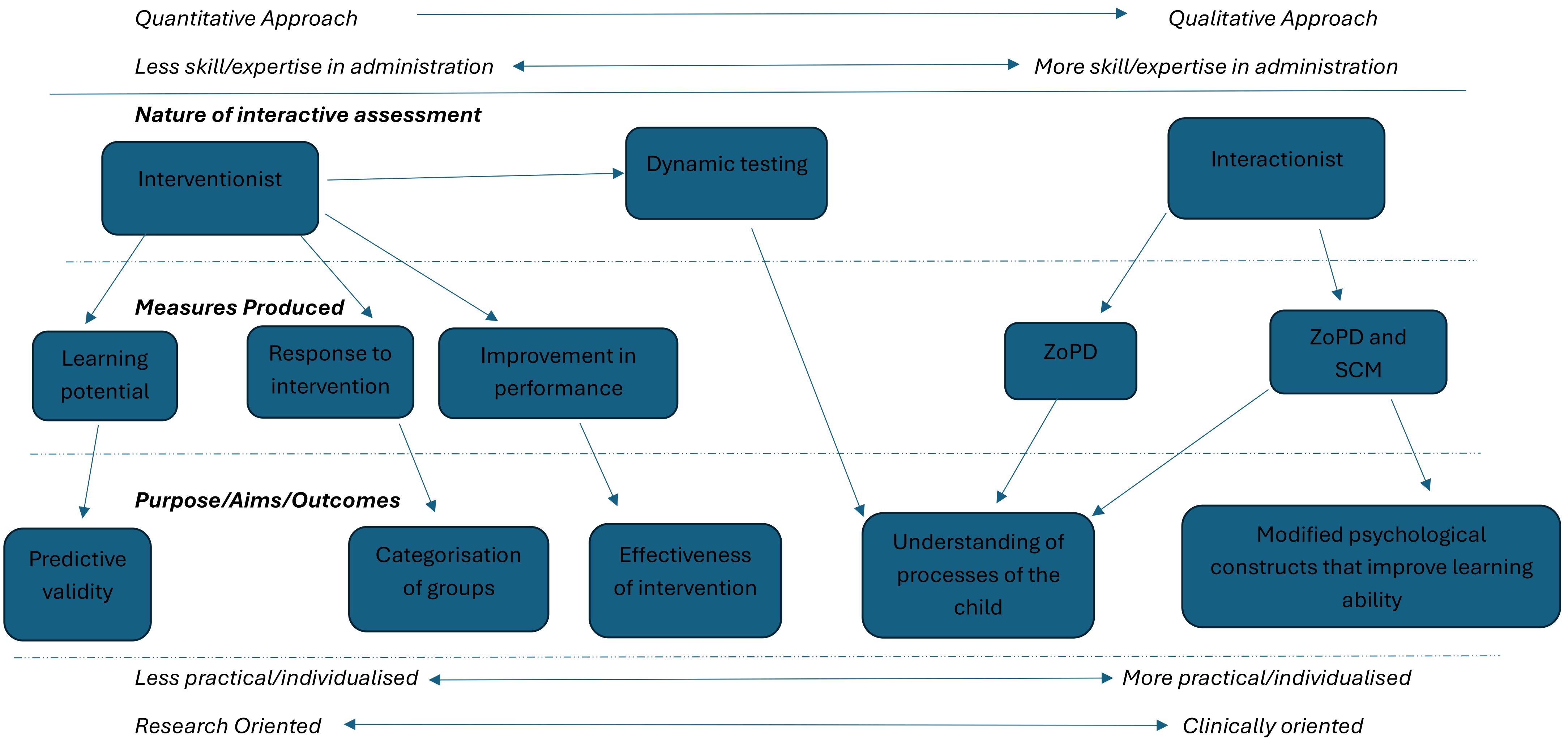
5.5.1. Relevant Dimensions and Categorisations of Dynamic Assessment that Inform the Implications of the Current Study.

Elliott and colleagues, (2003, 2018) raise the issue of the importance of precision when referring to what branch of dynamic assessment is relevant to the discussion. Broadly, a quantitative/qualitative or interventionist/interactionist divide has been identified throughout this thesis. A further distinction has been drawn within the interactionist branch. This relates to dynamic assessment which is informed solely by the theoretical framework of the zone of proximal development (Vygotsky & Cole, 1978) and dynamic assessment which is also informed by components of the theory of structural cognitive modifiability (Feuerstein et al., 1991). For example, a flexible, interactive assessment in maths may be implemented with the aim to improve understanding of the conceptualisations of the child, with interactions or prompts informed by specialist subject knowledge (e.g. Moscardini & Moscardini, 2020). Such an approach however does not embrace all components of the theory of SCM with the aim to enhance specific cognitive structures and promote autonomy of the learner as proposed by Feuerstein (Lauchlan & Daly, 2023).

This terminology adds further to the breadth of categorisations offered throughout this project to define dynamic assessment. Figure 8 provides a visual to support the key concepts referred to. As depicted, there is a trade-off between the quality of individual information garnered from the assessment and the requisite skills and expertise required to conduct the assessment (Fuchs et al., 2008). Approaches on the left-hand side of the chart at Figure 8, require less individual expertise in administration but produce less individualised practical information, with the opposite being true of both variables at the other end of the diagram. How does this inform the practical implications of the current study?

Figure 8

Various dimensions and categorisations defined relevant to dynamic assessment. Source: author.



The current study offers no comment on the potential uses for quantitative, interventionist approaches to DA that are focused on predicting future achievement (Fuchs et al., 2008), classifying groups based on learning needs (Cho et al., 2020) or assessing the efficacy of computerised intervention programmes (Wang, 2014; Wu et al., 2017). The construction of such measures to be used on a large scale within schools is the remit of educational researchers and is not comparable to the applications of an individualised approach to dynamic assessment. Consistent with a model of service delivery that aligns with prevention science (National Educational Psychological Service, 2020), it may well be of interest to the National Educational Psychological Service (NEPS) to invest resources in developing measures that would more accurately define learning support needs based on response to intervention and this may particularly be relevant to culturally and linguistically diverse populations (e.g. Cho et al., 2020). Such tools would follow a set protocol and require limited expertise to administer. However, the current discussion is reserved for considerations of dynamic assessment that align with an individualised/interactionist approach.

5.5.2. Implications of the Use of an Individualised, Interactionist Approach to Dynamic Assessment within Schools.

The findings of the current study have implications for the use of an individualised approach to dynamic assessment consistent with both branches of interactionist methodologies. Figure 8 succinctly depicts the circumstances under which the implementation of such an approach is appropriate. It is proposed that the expectations or aims for the assessment process is the first dimension to be considered in contemplation of the potential use of dynamic assessment within schools. Therefore, either as an internal process or as a result of a collaboration with an external agency such as the NEPS, the first question the school may ask is “what do we hope to gain from conducting this assessment?”

For example, if the schools wish to conduct an assessment with a student in order to categorise their level of maths achievement, an individualised maths dynamic assessment is not appropriate. In such circumstances scores on a standardised assessment may be consulted. However, if the aim of the assessment is to gain an insight into the individual processes of the student related to maths achievement and uncover potential useful approaches to support their learning an individualised maths dynamic assessment may be implemented. A less cluttered new primary maths curriculum intends to give teachers more autonomy to conduct such an assessment process within the school (NCCA, 2016, 2023)

5.5.2.1. The Role of Teachers in the Implementation of Dynamic Assessment. Such an approach is consistent with guidelines in relation to assessment outlined by the National Council for Curriculum and Assessment (2008), that suggest the aim of assessment should be to garner information in relation to both how the child learns (process) and what the child learns (content). Assessment for learning is seen as a critical assessment process that determines where the child is in their learning, where they are going, and how do they get there (NCCA, 2008). These basic tenets align with the theory of the zone of proximal development that underlies dynamic assessment (Vygotsky & Cole, 1978). Moreover, Leung, (2007) outline principles of assessment for learning that more closely marries the concept to dynamic assessment such as emphasising the importance of acknowledging affective factors in learning and promoting self-reflection. In an Irish schools context assessment for learning practices result in improved mathematical confidence and engagement with the content on the part of the pupil (Gurhy, 2017).

An individualised MDA that is informed by specialist subject knowledge on the part of the teacher to determine the processes employed by the student and their zone of proximal development (Vygotsky & Cole, 1978) would be consistent with assessment for learning and dynamic assessment principles. Therefore, it may be the case that both classroom and special education teachers are already engaging in practices like this on a wider scale within Irish primary schools.

Congruent with findings that students perceive an interactive assessment positively, teachers also have positive regard towards dynamic assessment and its principles. Teacher evaluations from the current study suggest they perceive dynamic assessment as a positive strengths-based model of assessment that provides practical recommendations and this has also been observed within the literature previously (Lawrence & Cahill, 2014). What factors therefore influence the implementation of such an approach on the part of teachers?

Elliott et al. (2018) point to the distinction on the right-hand side of the diagram at Figure 8 to explain the caution on the part of teachers in discussing and implementing dynamic assessment practices. They suggest that many dynamic approaches rely significantly on Feuerstein's intricate theory of structural cognitive modifiability and mediated learning experience (Feuerstein et al., 1991). Teachers who are not familiar with these concepts and related components such as scaffolded instruction, metacognition, and self-regulation, may face challenges in understanding assessment findings and implementing recommendations.

A distinction must therefore be made in relation to the implications of the findings of the current study. Firstly, an individualised approach to dynamic assessment which is consistent with the tenets of assessment for learning and informed by the theory of the zone of proximal development (Vygotsky & Cole, 1978), can prove useful in improving the understanding of the processes employed by the pupil. Secondly, the understanding of the concepts of mediated learning experiences, and affective and cognitive learning functions as proposed by Feuerstein (1991), are central to administration of dynamic assessment as it is conceptualised by experts within the field (Green & Birch, 2019) but the advent of these factors potentially move dynamic assessment beyond the remit of the school staff (Elliott et al., 2018).

5.5.2.2. The Potential Implications of the Current Project for the Educational Psychologist. Do the findings of the current study then have implications for educational psychologists in relation to the administration of maths dynamic assessments? Results from the current study are strongly suggestive that a maths dynamic assessment procedure can elucidate insights into a child's processes related to maths which may form the part of a larger formulation. A dynamic assessment informed by mediated learning experiences and learning constructs (Feuerstein et al., 1991), that aims to increase learning propensity however is more complex and time-consuming. This investment of time is incongruent with the NEPS' model of service delivery which is moving towards a consultation based and capacity building model (National Educational Psychological Service, 2020). Therefore, while a maths dynamic assessment can be used by educational psychologists to support a formulation with reference to the maths achievement, the utilisation of this approach to foster cognitive development presents some barriers to practicing EPs.

Potential solutions in relation to this would be for the NEPS to provide training to classroom and special education teachers in relation to practicing dynamic assessment. Teachers can with relevant training appropriate dynamic assessment skills (e.g. Davin et al., 2017; Davin & Herazo, 2020). Alternatively the Cognitive Abilities Profile (CAP) is a consultation tool based on the principles of dynamic assessment which was designed to bridge the gap in language between educational psychologist and teacher (Hill, 2015). Although such a tool is domain general and not specifically targeted at maths, the CAP could potentially inform service provision which is both informed by the principles of dynamic assessment and congruent with NEPS' model of service delivery.

Finally, to more clearly understand the implications of the current study within schools and in educational psychology practice it is acknowledged that much more data is needed to assess whether teachers value this approach as meeting the needs of their school. While the role of the educational psychologist in Ireland has moved towards a consultation-based model there is still a desire amongst many schools for their service provision from NEPS to consist of a standardised assessment. Also reflective of information from teacher semi-structured interviews in the current investigation it appears to be comparatively rare that students are referred for support from the NEPS for isolated difficulties in maths that aren't part of a larger formulation or query. Therefore, referring back to the diagram at Figure 8, and reflecting on the suggested question that schools should pose when considering a dynamic assessment of "what do we hope to gain from conducting this assessment?", it appears unlikely that schools would prioritise input from NEPS with the sole hope of gaining an improved understanding of the conceptualisations of the child in relation to maths.

5.5.2.3. Summary Related to Implications. In conclusion, the current study has a number of implications for educational psychology practice within schools. The findings of the study show the incremental validity of conducting an individualised dynamic assessment which is informed by the theory of the zone of proximal development (Vygotsky & Cole, 1978) and specialised subject knowledge in maths. Using such an approach can elucidate the processes the child uses to complete maths tasks and may highlight misconceptions for targeted intervention. This is consistent with guidelines from the NCCA (2008) in relation to conducting assessment for learning which has been shown to have positive outcomes (Gurhy, 2017).

The additional benefit of conducting a dynamic assessment informed by the theory of structural cognitive modifiability (Feuerstein et al., 1991), is given strength by the findings of the current research with pupils identifying the relevance of mediated learning experiences in the dynamic assessment process. Barriers to implementing a dynamic assessment approach to targeting deficient learning functions and improving propensity to learn include the following:

- It is unclear how many maths dynamic assessment sessions would be needed to produce significant lasting improvement with some studies implementing mediation techniques in the classroom for a period of a year (Tzuriel et al., 2021).
- Teachers are not well informed on the intricacies of Feuerstein's theory which is a barrier to implementation of an individualised approach (Elliott et al., 2018).
- Conducting multiple dynamic assessment sessions as a NEPS educational psychologist may not be feasible and is not congruent with NEPS model of service delivery.
- It is unclear to what extent the current protocol would meet a need as schools don't often refer to the NEPS for support with the sole aim of gaining a greater understanding of the child's maths processes or conceptualisations.

These identified barriers present opportunities for future research.

5.6. Implications for Future Research

The current study has a number of implications for future research as it elucidates areas that require further investigation particularly with regard to potential implications for educational psychology practice. Future research should also address the design and methodological limitations of the current study. For example, future research may attempt to replicate and expand on the findings of the current study by implementing maths dynamic assessment with a practitioner with more comprehensive experience and skills in mediation that are more developed. Replicated findings would add reliability to the assertions of the current study in relation to how the benefits of implementing a dynamic assessment in schools are underpinned by both the theory of the zone of proximal development (Vygotsky & Cole, 1978) and structural cognitive modifiability (Feuerstein et al., 1991). Future studies aimed at replication may also incorporate follow up data to determine the putative longer term effects of improving propensity to learn (Tzuriel, 2013).

As previously alluded to research suggests that teachers view a dynamic assessment as strengths-based and this results in a more positive perception of the child (Lawrence & Cahill, 2014). Moreover more dated research suggests that teachers valued a report that consisted of a dynamic assessment task as an adjunct to a static test of mathematics (Bosma & Resing, 2010). Future research may further explore teacher's perceptions of dynamic assessment feedback and reports with a specific focus on recommendations that relate to Feuerstein's theory (1991), which can often be portrayed in esoteric language providing a stumbling block for teachers as noted by Elliott (2018). This may be explored with a particular focus in the Irish context.

Further to this, also within the Irish context, future research may look to explore teacher's expectations in relation to service provision from NEPS to support schools to support children with maths difficulties. Data from the current investigation speculates that teachers often don't suggest a child should receive input from the NEPS for isolated maths difficulties and in cases where such a presenting concern arises it is unclear what the expectations are for such input. As is depicted at Figure 8, if teachers do not pose the question to NEPS of "how can we better understand this child's processes related to maths?" and if this question can be adequately answered within the school, then future research in this area will not have implications for educational psychology practice.

5.7. Impact Statement

In summary, the research makes a clear contribution to the field of dynamic assessment. This was achieved by identifying an area that has been sparsely investigated which is the application of dynamic assessment in the domain of mathematics within schools. In the course of investigation of this area a number of relevant findings were made with practical relevance. The thesis offers a comprehensive review of dynamic assessment as a construct with a number of important dimensions and categories identified. This overview points to a key distinction between interventionist and interactionist approaches. Within the interactionist branch a further delineation is provided i.e. approaches underpinned by the zone of proximal development (Vygotsky & Cole, 1978), and structural cognitive modifiability (Feuerstein et al., 1991).

The current research undertaking is the first to use a qualitative approach to explore dynamic assessment in maths with an analysis informed by both of these theories. Findings that elucidate empirical patterns consistent with the zone of proximal development (Vygotsky & Cole, 1978) certainly have implications for teachers in relation to how they may use assessment for learning to support children in development of maths understanding (NCCA, 2008). Findings that elucidate empirical patterns consistent with the theory of structural cognitive modifiability (Feuerstein et al., 1991) suggest that the role of the mediator can help to improve maths achievement for a pupil experiencing maths difficulties. The data from this study suggests that dynamic assessment informed by Feuerstein's characteristics of mediated learning experiences can target and improve domain general cognitive functions which may contribute to improvement in maths attainment by improving the propensity of the pupil to learn (Feuerstein et al., 1991; Lauchlan & Daly, 2023). Further research is required to replicate these findings, provide data related to the length of a putative dynamic assessment approach to casework, and teachers' expectations in relation to service provision from the NEPS.

5.8. Summary and Concluding Remarks

To conclude, this research project in the area of mathematics and dynamic assessment has given an overview of relevant contextual factors that underlie this investigation, including the impending introduction of the new primary school curriculum in Ireland (NCCA 2023), and the role of educational psychologists within the NEPS in supporting schools. An overview of the theoretical foundations of dynamic assessment incorporating the zone of proximal development (Vygotsky & Cole, 1978) and structural cognitive modifiability (Feuerstein et al., 1991) frameworks reveals a connection between the principles underlying learning in mathematics and dynamic assessment. These principles include the goal to develop communication skills and autonomy in learning through social interaction and exploration (Dooley, 2019; Dooley et al., 2014; Feuerstein et al., 1991). Furthermore, a dynamic assessment approach aligns with policy documents in Ireland related to assessment for learning (NCCA, 2008).

Dynamic assessment refers to an assessment process that is interactive and embraces the role of the examiner in providing support that elucidates learning potential (Lidz, 1995). Procedures that fall under the umbrella of dynamic assessment are broad and vary along a number of dimensions and categories (Fuchs et al., 2008). The current research involves the investigation of the implementation of an individualised dynamic assessment for a pupil exhibiting mathematics difficulties. Patterns of empirical data identified are consistent with the patterns predicted by the ZoPD and SCM, suggesting that a MDA can reveal developing psychological constructs and can also improve mathematics achievement by targeting deficient cognitive constructs and improving propensity to learn through mediated learning experiences (Feuerstein et al., 1991).

The results of this research have implications for schools as this study exemplifies how dynamic assessment can be used to determine the procedural and conceptual understanding of a student with maths difficulties consistent with the guidelines outlined by the NCCA (2008). These findings are consistent with previous literature (Moscardini & Moscardini, 2020). The implementation of a maths dynamic assessment informed by core learning functions and mediated learning experiences defined by Feuerstein (1991) is heavy with esoteric language and this provides a barrier for teachers to implement this approach (Elliott et al., 2018). The implications of the findings of this research for educational psychologists are that this approach may improve the propensity of a student with mathematics difficulties to learn in this domain and so this may be an effective approach to direct casework. Future research is needed to determine if effects are maintained at follow up, the number of sessions required for meaningful change and the extent to which such an approach would meet the needs of the school with regard to service provision from the national educational psychology service.

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Tzuriel, D., & Shomron, V. (2018). The effects of mother-child mediated learning strategies on psychological resilience and cognitive modifiability of boys with learning disability. *British Journal of Educational Psychology*, *88*(2), 236–260. https://doi.org/10.1111/bjep.12219

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Wu, H.-M., Kuo, B.-C., & Wang, S.-C. (2017). Computerized dynamic adaptive tests with immediately individualized feedback for primary school mathematics learning. *Journal of Educational Technology & Society*, *20*(1), 61–72.

Xu, F., & Spelke, E. S. (2000). Large number discrimination in 6-month-old infants. *Cognition*, *74*(1), B1–B11. https://doi.org/10.1016/S0010-0277(99)00066-9

Xu, F., Spelke, E. S., & Goddard, S. (2005). Number sense in human infants. *Developmental Science*, *8*(1), 88–101. https://doi.org/10.1111/j.1467-7687.2005.00395.x

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Appendix 1

List of Excluded Studies and Rationale for Exclusion

Study	Reason for Exclusion as Listed in Table 1
Adams, H. B., & Wallace, B. (1988). The Assessment and Development of Potential of High School Pupils in the Third World Context of Kwa-Zulu/Natal: Part III Developing Higher Order Thinking Skills and Problem Solving Strategies in a Co-Operative Learning Environment. *Gifted Education International*, *5*(3), 132–137. Scopus. https://doi.org/10.1177/026142948800500302	Not MDA
Adams, H. B., & Wallace, B. (1991). TASC: A Model for Curriculum Development: A Model for Curriculum Development Which Could Have application in A Wide Variety of Social, Economic and Political Situations.: Developing the Potential of Children in Disadvantaged Communities: The TASC Project: "Thinking Actively in a Social Context." *Gifted Education International*, *7*(3), 104–113. Scopus. https://doi.org/10.1177/026142949100700302	Not primary empirical research
Al-Hilawani, Y. A. (2001). Examining metacognition in hearing and deaf/hard of hearing students: A comparative study. *American Annals of the Deaf*, *146*(1), 45–50. Education Collection. https://doi.org/10.1353/aad.2012.0101	Not MDA
Al-Hilawani, Y. A. (2003). Measuring students' metacognition in real-life situations. *American Annals of the Deaf*, *148*(3), 233–242. Education Collection. https://doi.org/10.1353/aad.2003.0016	Not MDA
Al-Hroub, A., & Whitebread, D. (2008). Teacher nomination of "mathematically gifted children with specific learning difficulties" at three state schools in Jordan. British Journal of Special Education, 35(3), 152–164. Scopus. https://doi.org/10.1111/j.1467-8578.2008.00379.x	Not MDA
Al-Khoury, R., Scarpas, A., Kasbergen, C., & Blaauwendraad, J. (2002). Spectral element technique for efficient parameter identification of layered media. Part III: Viscoelastic aspects. *International Journal of Solids and Structures*, *39*(8), 2189–2201. Scopus. https://doi.org/10.1016/S0020-7683(02)00079-3	Not MDA
Arbulu, M., Oregi, X., & Etxepare, L. (2023). Environmental and economic optimization and prioritization tool-kit for residential building renovation strategies with life cycle approach. *Building and Environment*, *228*. Scopus. https://doi.org/10.1016/j.buildenv.2022.109813	Not MDA
Askew, M. (2013). Mediating Learning Number Bonds through a Vygotskian Lens of Scientific Concepts. South African Journal of Childhood Education, 3(2), 1–20. ERIC; Social Science Premium Collection.	Not primary empirical research

Attali, Y., Laitusis, C., & Stone, E. (2016). Differences in reaction to immediate feedback and opportunity to revise answers for multiple-choice and open-ended questions. *Educational and Psychological Measurement*, *76*(5), 787–802. APA PsycInfo. https://doi.org/10.1177/0013164415612548	Not primary school sample
Bonelli, A., Bursi, O., He, L., Magonette, G., & Pegon, P. (2008). Convergence analysis of a parallel interfield method for heterogeneous simulations with dynamic substructuring. *INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN ENGINEERING*, *75*(7), 800–825. https://doi.org/10.1002/nme.2285	Does not include MDA
Bonete, S., Vives, M. C., Fernández-Parra, A., Calero, M. D., & García-Martín, M. B. (2010). Learning potential and social skills in children with asperger disorder. *Behavioral Psychology/ Psicologia Conductual*, *18*(3), 473–490. Scopus.	Does not include MDA
Bosma, T., & Resing, W. C. M. (2010). Teacher's appraisal of dynamic assessment outcomes: Recommendations for weak mathematics-performers. *Journal of Cognitive Education and Psychology*, *9*(2), 91–115. APA PsycInfo. https://doi.org/10.1891/1945-8959.9.2.91	Measure of teachers assessment of dynamic assessment – Does not include MDA
Brandell, E. E., Dobson, A. P., Hudson, P. J., Cross, P. C., & Smith, D. W. (2021). A metapopulation model of social group dynamics and disease applied to Yellowstone wolves. *PNAS Proceedings of the National Academy of Sciences of the United States of America*, *118*(10). APA PsycInfo. https://doi.org/10.1073/pnas.2020023118	No measure of maths dynamic assessment
Canales, F. A., Jurasz, J., Kies, A., Beluco, A., Arrieta-Castro, M., & Peralta-Cayón, A. (2020). Spatial representation of temporal complementarity between three variable energy sources using correlation coefficients and compromise programming. *MethodsX*, *7*. Scopus. https://doi.org/10.1016/j.mex.2020.100871	No measure of maths dynamic assessment
Carlson, J. S., & Wiedl, K. H. (1980). Applications of a dynamic testing approach in intelligence assessment: Empirical results and theoretical formulations. *Zeitschrift Für Differentielle Und Diagnostische Psychologie*, *1*(4), 303–318. APA PsycInfo.	Not primary source
Chebotareva, G. S., Strielkowski, W., & Gafurov, N. S. (2020). Applicability of forecasted bankruptcy models to Russian industrial companies. *Bulletin of the South Ural State University, Series: Mathematical Modelling, Programming and Computer Software*, *13*(3), 98–102. Scopus. https://doi.org/10.14529/mmp200311	No measure of maths dynamic assessment
Cho, E., & Compton, D. (2015). Construct and incremental validity of dynamic assessment of decoding within and across domains. *LEARNING AND INDIVIDUAL DIFFERENCES*, *37*, 183–196. https://doi.org/10.1016/j.lindif.2014.10.004	No measure of maths dynamic assessment

Cho Eunsoo, Compton, D. L., & Josol Cynde Katherine. (2020). Dynamic assessment as a screening tool for early identification of reading disabilities: A latent change score approach. *Reading and Writing*, *33*(3), 719–739. Education Collection. https://doi.org/10.1007/s11145-019-09984-1	No measure of maths dynamic assessment
Clark, I. (2015). Formative assessment: Translating high-level curriculum principles into classroom practice. *The Curriculum Journal*, *26*(1), 91. Education Collection.	No measure of maths dynamic assessment
Crosson, A. C., & McKeown, M. G. (2016). Middle School Learners' Use of Latin Roots to Infer the Meaning of Unfamiliar Words. *Cognition and Instruction*, *34*(2), 148–171. Education Collection. https://doi.org/10.1080/07370008.2016.1145121	No measure of maths dynamic assessment
Dash, M., & Khan, F. (2001). Impact of guided learning on the cognitive performance of low and high achievers. *Psychological Studies*, *46*(1–2), 14–20. APA PsycInfo.	Not maths dynamic assessment
Dawson, D. R., Gaya, A., Hunt, A., Levine, B., Lemsky, C., & Polatajko, H. J. (2009). Using the Cognitive Orientation to Occupational Performance (CO-OP) with adults with executive dysfunction following traumatic brain injury. *The Canadian Journal of Occupational Therapy*, *76*(2), 115–127. Education Collection.	No measure of maths dynamic assessment
de Beer, M. (2011). The role of the Learning Potential Computerised Adaptive Test (LPCAT) in the vocational guidance assessment of adolescents. *Educational and Child Psychology*, *28*(2), 114–129. APA PsycInfo.	Not primary school children
Della Toffalo, D. A., & Milke, R. M. (2008). Test reviews: Dynamic assessment of test accommodations. *Journal of Psychoeducational Assessment*, *26*(1), 83–91. APA PsycInfo. https://doi.org/10.1177/0734282907300568	Review – not primary empirical research
Drygala, I. J., & Dulinska, J. M. (2019). Full-scale experimental and numerical investigations on the modal parameters of a single-span steel-frame footbridge. *Symmetry*, *11*(3). Scopus. https://doi.org/10.3390/sym11030404	No measure of maths dynamic assessment
Elliott, J. G., Resing, W. C. M., & Beckmann, J. F. (2018). Dynamic Assessment: A Case of Unfulfilled Potential? *Educational Review*, *70*(1), 7–17. Education Collection; ERIC. https://doi.org/10.1080/00131911.2018.1396806	Review – not primary empirical research
Embretson, S. E. (1987). Improving the measurement of spatial aptitude by dynamic testing. *Intelligence*, *11*(4), 333–358. APA PsycInfo. https://doi.org/10.1016/0160-2896(87)90016-X	Not maths dynamic assessment
Embretson, S. E. (2000). Multidimensional measurement from dynamic tests: Abstract reasoning under stress. *Multivariate Behavioral Research*, *35*(4), 505–542. APA PsycInfo. https://doi.org/10.1207/S15327906MBR3504_05	Not maths dynamic assessment
Endepohls-Ulpe, M. (2017). Acceleration, Enrichment, or Internal Differentiation – Consequences of Measures to Promote Gifted Students Anticipated by German Secondary School Teachers. *Electronic Journal of Research in*	Not primary school children sample

Educational Psychology, *15(1)*(41), 147–163. Scopus. https://doi.org/10.14204/ejrep.41.15173	
Fabio, R. A. (2005). Dynamic Assessment of Intelligence Is a Better Reply to Adaptive Behavior and Cognitive Plasticity. *Journal of General Psychology*, *132*(1), 41–64. APA PsycInfo. https://doi.org/10.3200/GENP.132.1.41-66	Not dynamic assessment of a maths task
Feissel, P., & Allix, O. (2007). Modified constitutive relation error identification strategy for transient dynamics with corrupted data: The elastic case. *COMPUTER METHODS IN APPLIED MECHANICS AND ENGINEERING*, *196*(13–16), 1968–1983. https://doi.org/10.1016/j.cma.2006.10.005	Not dynamic assessment of a maths task
Floyd, R. G., Bergeron, R., & Alfonso, V. C. (2006). Cattell-Horn-Carroll cognitive ability profiles of poor comprehenders. *Reading and Writing*, *19*(5), 427–456. Scopus. https://doi.org/10.1007/s11145-006-9002-5	Not dynamic assessment of a maths task
Frederiksen, C. H., & Donin, J. (1999). Cognitive assessment in coached learning environments. *Alberta Journal of Educational Research*, *45*(4), 392. Education Collection.	Not dynamic assessment of a maths task
Fuchs, D., & Fuchs, L. S. (2006). Introduction to Response to Intervention: What, why, and how valid is it? *Reading Research Quarterly*, *41*(1), 93–99. APA PsycInfo. https://doi.org/10.1598/RRQ.41.1.4	Not dynamic assessment of a maths task
Gerber, M. M., Semmel, D. S., & Semmel, M. I. (1994). Computer-based dynamic assessment of multidigit multiplication. *Exceptional Children*, *61*(2), 114. Education Collection.	Not primary school children
Geurts, N. E. (2006). Mathematics for everyone: A pilot project of teaching maths to children with intellectual impairment. *Erdélyi Pszichológiai Szemle*, *Spec Iss2,Suppl, Part 2*, 241–250. APA PsycInfo.	Can not access
Gonzalez, H., Palencia, A., Umana, L., Galindo, L., & Villafrade, L. (2008). Mediated learning experience and concept maps: A pedagogical tool for achieving meaningful learning in medical physiology students. *ADVANCES IN PHYSIOLOGY EDUCATION*, *32*(4), 312–316. https://doi.org/10.1152/advan.00021.2007	Not primary school children
Grapin, S. E., & Llosa, L. (2022). Dynamic Assessment of English Learners in the Content Areas: An Exploratory Study in Fifth-Grade Science. *TESOL Quarterly*, *56*(1), 201–229. Scopus. https://doi.org/10.1002/tesq.3059	Not maths dynamic assessment
Guthke, J., & Stein, H. (1996). Are learning tests the better version of intelligence tests? *European Journal of Psychological Assessment*, *12*(1), 1–13. Scopus. https://doi.org/10.1027/1015-5759.12.1.1	Not primary empirical research
Haeck, W., Yeld, N., Conradie, J., Robertson, N., & Shall, A. (1997). A developmental approach to mathematics testing for university admissions and course placement. *Educational Studies in Mathematics*, *33*(1), 71–91. Scopus. https://doi.org/10.1023/A:1002974021690	Not primary school sample

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Tzuriel, D., & George, T. (2009a). Improvement of analogical reasoning and academic achievement by the Analogical Reasoning Programme (ARP). *Educational and Child Psychology*, *26*(3), 71–94. APA PsycInfo.	No maths dynamic assessment
Tzuriel, D., & George, T. (2009b). Improvement of analogical reasoning and academic achievements by the Analogical Reasoning Programme (ARP). *Educational and Child Psychology*, *26*(3), 71–94. Scopus.	No maths dynamic assessment
Tzuriel, D., & Groman, T. (2017). Dynamic Assessment of Figurative Language of Children in the Autistic Spectrum: The Relation to Some Cognitive and Language Aspects. *Journal of Cognitive Education and Psychology, Suppl. SPECIAL ISSUE ON COGNITION AND PSYCHOPATHOLOGY*, *16*(1), 38–63. Education Collection. https://doi.org/10.1891/1945-8959.16.1.38	No maths dynamic assessment
Tzuriel, D., Hanuka-Levy, D., & Kashy-Rosenbaum, G. (2022). Dynamic Assessment of Self-Regulation and Planning Behavior. *Frontiers in Education*, *7*. Scopus. https://doi.org/10.3389/feduc.2022.885170	Not maths dynamic assessment
Tzuriel, D., Kaniel, S., Kanner, E., & Haywood, H. C. (1999). Effects of the "Bright Start" program in kindergarten on transfer and academic achievement. *Early Childhood Research Quarterly*, *14*(1), 111–141. APA PsycInfo. https://doi.org/10.1016/S0885-2006(99)80009-X	Not maths dynamic assessment
Tzuriel, D., Kedmi, G. E., & Passig, D. (2021). Cognitive modifiability in 3D-IVR and 2D computerized environments: The effects of rotation of information resources and shift of viewing angles. *Sustainability (Switzerland)*, *13*(6). Scopus. https://doi.org/10.3390/su13063520	Not maths dynamic assessment

Tzuriel, D., & Shamir, A. (2002). The effects of mediation in computer assisted dynamic assessment: Mediation in computer assisted dynamic assessment. *Journal of Computer Assisted Learning*, *18*(1), 21–32. https://doi.org/10.1046/j.0266-4909.2001.00204.x	Not maths dynamic asssessment
Tzuriel, D., & Shamir, A. (2010). Mediation strategies and cognitive modifiability in young children as a function of Peer Mediation with Young Children program and training in analogies versus math tasks. Journal of Cognitive Education and Psychology, 9(1), 48–72. APA PsycInfo. https://doi.org/10.1891/1945-8959.9.1.48	MDA used to assess a program that promotes Mediated learning experiences in peer diads
Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment Strategies for Enhancing Students' Mathematical Problem-solving Skills: A Review of Literature. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(3), 1–10. Scopus. https://doi.org/10.29333/ejmste/9728	Not primary empirical research
Vakili, S., & Ebadi, S. (2019). Investigating Contextual Effects on Iranian EFL Learners' Mediation and Reciprocity in Academic Writing. *Cogent Education*, *6*(1), 1–26. Education Collection; ERIC. https://doi.org/10.1080/2331186X.2019.1571289	Not maths dynamic assessment
Veerbeek, J., Vogelaar, B., Verhaegh, J., & Resing, W. C. M. (2019a). Process Assessment in Dynamic Testing Using Electronic Tangibles. *Journal of Computer Assisted Learning*, *35*(1), 127–142. Education Collection; ERIC. https://doi.org/10.1111/jcal.12318	Not maths dynamic assessment
Veerbeek, J., Vogelaar, B., Verhaegh, J., & Resing, W. C. M. (2019b). Process Assessment in Dynamic Testing Using Electronic Tangibles. *Journal of Computer Assisted Learning*, *35*(1), 127–142. Education Collection; ERIC. https://doi.org/10.1111/jcal.12318	Not maths dynamic assessment
Vogelaar, B., Bakker, M., Hoogeveen, L., & Resing, W. C. M. (2017). Dynamic Testing of Gifted and Average-Ability Children's Analogy Problem Solving: Does Executive Functioning Play a Role? *Psychology in the Schools*, *54*(8), 837–851. Education Collection; ERIC. https://doi.org/10.1002/pits.22032	Not maths dynamic assessment
Vogelaar, B., & Resing, W. C. M. (2018). Changes over time and transfer of analogy-problem solving of gifted and non-gifted children in a dynamic testing setting. *Educational Psychology*, *38*(7), 898–914. Education Collection. https://doi.org/10.1080/01443410.2017.1409886	Not maths dynamic assessment
Vogelaar, B., Sweijen, S., & Resing, W. (2019). Gifted and Average-Ability Children's Potential for Solving Analogy Items. *JOURNAL OF INTELLIGENCE*, *7*(3). https://doi.org/10.3390/jintelligence7030019	Not maths dynamic assessment
Vogelaar, B., Veerbeek, J., Splinter, S. E., & Resing, W. C. M. (2021). Computerized dynamic testing of children's potential for reasoning by analogy: The role of executive	Not maths dynamic assessment

functioning. *Journal of Computer Assisted Learning*, *37*(3), 632–644. Education Collection. https://doi.org/10.1111/jcal.12512	
Volkova, M., Granichin, O., Volkov, G., & Petrov, Y. (2018). On the Possibility of Using the Method of Sign-Perturbed Sums for the Processing of Dynamic Test Data. *VESTNIK ST PETERSBURG UNIVERSITY-MATHEMATICS*, *51*(1), 23–30. https://doi.org/10.3103/S1063454118010132	Not maths dynamic assessment
Vulić, I., Altaras Dimitrijević, A., & Jolić Marjanović, Z. (2014). Teachers' ratings of the informativeness and usefuleness of cognitive assessment reports: Does dynamic assessment make a difference? *Zbornik Instituta Za Pedagoska Istrazivanja*, *46*(1), 118–144. Scopus. https://doi.org/10.2298/ZIPI1401118V	Not primary school children
Wang, M.-T., Ye, F., & Degol, J. L. (2017). Who Chooses STEM Careers? Using A Relative Cognitive Strength and Interest Model to Predict Careers in Science, Technology, Engineering, and Mathematics. *Journal of Youth and Adolescence*, *46*(8), 1805–1820. Scopus. https://doi.org/10.1007/s10964-016-0618-8	Not maths dynamic assessment
White, R., & Dinos, S. (2010). Investigating the Impact of Mediated Learning Experiences on Cooperative Peer Communication During Group Initiatives. *The Journal of Experiential Education*, *32*(3), 226–238. Education Collection.	Not maths dynamic assessment
Wiedl, K. H., Schöttke, H., Green, M. F., & Nuechterlein, K. H. (2004a). Dynamic Testing in Schizophrenia: Does Training Change the Construct Validity of a Test? *Schizophrenia Bulletin*, *30*(4), 703–711. APA PsycArticles. https://doi.org/10.1093/oxfordjournals.schbul.a007124	Not maths dynamic assessment
Wiedl, K. H., Schöttke, H., Green, M. F., & Nuechterlein, K. H. (2004b). Dynamic Testing in Schizophrenia: Does Training Change the Construct Validity of a Test? *Schizophrenia Bulletin*, *30*(4), 703–711. APA PsycInfo. https://doi.org/10.1093/oxfordjournals.schbul.a007124	Not maths dynamic assessment
Wijnen, F., Walma van der Molen, J., & Voogt, J. (2023). Primary teachers' attitudes towards using new technology and stimulating higher-order thinking in students: A profile analysis. *Education and Information Technologies*, *28*(6), 6347–6372. Education Collection. https://doi.org/10.1007/s10639-022-11413-w	Not primary school students
Xu, L., & Zhai, W. (2019). A three-dimensional dynamic model for train-track interactions. *Applied Mathematical Modelling*, *76*, 443–465. Scopus. https://doi.org/10.1016/j.apm.2019.04.037	Not maths dynamic assessment
Yang, S. C. (2001). Language learning on the World Wide Web: An investigation of EFL learners' attitudes and perceptions. *Journal of Educational Computing Research*, *24*(2), 155–181. Scopus. https://doi.org/10.2190/VDJC-FGTQ-79FH-M615	Not maths dynamic assessment

Zaaiman, H., van der Flier, H., & Thijs, G. D. (2001). Dynamic testing in selection for an educational programme: Assessing South African performance on the Raven Progressive Matrices. *International Journal of Selection and Assessment*, *9*(3), 258–269. APA PsycInfo. https://doi.org/10.1111/1468-2389.00178	Not maths dynamic assessment
Zhang, H. S., & Van Compernolle, R. A. (2016). Learning potential and the dynamic assessment of L2 chinese grammar through elicited imitation. *Language and Sociocultural Theory*, *3*(1), 99–119. Scopus. https://doi.org/10.1558/lst.v3i1.27549	Not maths dynamic assessment
Zhang, J., Gao, M., Holmes, W., Mavrikis, M., & Ma, N. (2021). Interaction patterns in exploratory learning environments for mathematics: A sequential analysis of feedback and external representations in Chinese schools. Interactive Learning Environments, 29(7), 1211-1228.	Not MDA

Appendix 2

General Scoring Procedure to Assign Weight of Evidence for Included Studies in the Systematic Review

Each study was assigned a score of one, two or three under the categories Weight of Evidence (WoE) A, B and C. These scores were then added and divided by three to discern the score attributed under WoED. A total score of between 1-1.6 yielded an overall low quality of evidence appraisal. A score between 1.6-2.3 yielded a medium appraisal, while a score between 2.3 and 3 yielded an appraisal of high-quality evidence.

Weight of Evidence A. Under WoEA studies were attributed scores according to relevant quality indicator frameworks. Such frameworks outline key characteristics that indicate the study was carried out to an appropriate standard. Different study designs have different quality indicators and so for the purpose of this review three frameworks were used. Gersten, et al. (2005) designed a quality indicators framework to be used in the appraisal of group experimental studies in special education. This framework was appropriately used for the appraisal of six studies that used an experimental design to assess the effects of MDA within a primary school sample with special educational needs (Al-Hroub, 2021; Al-Hroub & Whitebread, 2019; Bosma et al., 2017; Brownell et al., 1993; Peltenburg et al., 2009; Popa & Pauc, 2015). The framework was also used for the appraisal of two further studies that displayed group experimental designs but samples obtained were of the general student population as opposed to those with special educational needs (Wang, 2014; Wu et al., 2017). In these cases, the application of this framework was deemed appropriate in the name of consistency as there was only one quality indicator that pertained specifically to the definition of the SEN sample obtained, which is not relevant for the latter two studies.

Gersten et al. (2005), provide a scoring framework and suggest a study may be deemed of high quality if they meet all but one of the essential criteria and meet at least four desirable criteria. A study will be deemed of acceptable quality if it meets all but one of the essential criteria and at least one of the desirable criteria outlined. For the purpose of the current review, studies were deemed of high or medium quality respectively in accordance with the standards outlined above and were deemed of low quality if they did not meet these standards. An example of scoring of three included studies using Gersten's appraisal framework (2005) can be seen at Appendix 3.

The second quality appraisal framework utilized was The American Educational Research Association (AERA) published "Standards for Reporting on Empirical Social Science Research in AERA Publications," (2006). These reporting standards are divided into eight general areas and separate criteria are provided for quantitative and qualitative studies. An adapted version of these standards was used to appraise five quantitative analytical cross-sectional studies (Cho et al., 2020; Fuchs et al., 2008, 2011; Seethaler et al., 2012, 2016). Scoring for each of the five studies utilizing this framework can be seen at Appendix 4.

The original publication offers no guidance in defining cut off scores for classification of studies as high, medium or low quality. Therefore, cutoff scores for these classifications were determined to approximate the standards outset by Gersten et al. (2005), which outline a minimum score of 10 for a medium quality categorization and minimum score of 13 for a high-quality classification. To account for an extra item in this framework these scores were adjusted. Scores under 11 were attributed a low-quality classification, scores between 11 and 14 inclusive, were considered medium quality while scores of 15 and over were classified as high-quality evidence.

Finally, the study conducted by Moscardini and Moscardini, (2020), was evaluated with the use of a quality indicators framework specifically for case study research (Hyett et al., 2014). This framework consisted of 23 items and cutoff scores for classifications were made to approximate the other frameworks. In this case a minimum score of 14 was the cutoff for medium quality appraisal while a minimum score of 18 was the cutoff for high quality appraisal. Scoring for this study under each item of the aforementioned framework can be seen at Appendix 5.

Weight of Evidence B.

WoEB was quantified based on how appropriate the design of the study was to answer the research question. For this purpose, a three-tiered scoring system was developed. This is described in detail at Appendix 6.

Weight of Evidence C.

Scores for WoEC were assigned based on the defining characteristics of dynamic assessment procedures outlined by Haywood, (2012) namely that dynamic assessment is:

1) Idiographic
2) Process-focused
3) Places emphasis on educability

The studies were assigned a high rating if they were adjudged to be aligned with these three principles, and accordingly assigned a medium or low rating if they were aligned with two or one of these principles respectively. The extent to which each study aligns with these principles is outlined at Appendix 7.

Weight of Evidence D.

It may be acknowledged by an analysis of the criteria outlined above that it is impossible to obtain a rating of high quality across all categories. That is because qualitative techniques are graded as medium quality evidence under WoEB and one of Haywood’s defining characteristics of dynamic assessment – idiographic – is incongruent with quantitative research. Therefore, regardless of the design employed, no piece of evidence can be considered high quality across all categories in answering the research question. This phenomenon is acknowledged by the researcher and serves to highlight the difficulty in providing high quality empirical evidence for the effectiveness or validity of this approach as it is defined in the literature.

Appendix 3

WoEA Individual Item Scoring According to the Framework Set out by Gersten et al, (2005) for Eight Relevant Studies

Gersten et al., (2005) Criterion	**Bosma, T., Stevenson, C. E., & Resing, W. C. M. (2017).**	**Peltenburg, M., van den Heuvel-Panhuizen, M., & Robitzsch, A. (2010).**	**Popa, N. L., & Pauc, R. L. (2015).**
Was sufficient information provided to determine/confirm whether the participants demonstrated the disability(ies) or difficulties presented?	Yes - sample defined as 2nd grade students with arithmetic difficulties - recruited from 23 schools in the Netherlands - identified as having AD if they scored in the bottom 20%.	Yes - 37 and 43 students from 2 different schools for special education - identified as having learning difficulties not physical disabilities - aged 8-12 - maths level at "end of grade 2"	NA - design and research question does not pertain to a specific group, condition or disability
Were appropriate procedures used to increase the likelihood that relevant characteristics of participants in the sample were comparable across conditions?	Yes - a randomised block design was employed with blocking based on a short version of Ravens SPM - no difference between gender across conditions.	NA - one sample	No - quasi experimental study - dictated by two different classes
Was sufficient information given characterising the interventionists or teachers provided? Did it indicate whether they were comparable across conditions?	Yes	Yes - digitally presented	Yes - DA administered by teachers to avoid effects of external practitioners - teachers received necessary training
Was the intervention clearly described and specified?	Yes	Yes - use of digital manipulatives and number line available to the students	No - vaguely described and the scope of the intervention was not well outlined
Was the fidelity of implementation described and assessed?	Yes - extensive reference to this,	Yes - fidelity is not an issue as it was digitally administered	No - how the teacher implemented the intervention across the 8 weeks was not monitored or evaluated
Was the nature of services provided in comparison conditions described?	Yes- remained in classroom - passive control condition	NA - no comparison conditions	No

Were multiple measures used to provide an appropriate balance between measures closely aligned with the intervention and measures of generalized performance?	no	No	No
Were outcomes for capturing the intervention's effect measured at the appropriate times?	Yes	Yes	Yes
Were the data analysis techniques appropriately linked to key research questions and hypotheses? Were they appropriately linked to the unit of analysis in the study?	Yes - mixed factorial anova appropriate to test for differences in pre and post-test for the different groups - repeated measures ANOVA used to assess the decrease in number of prompts required across series 1-5, cluster analysis used for identification of 4 clusters based on prompts in scenario-protocols for the participants.	Yes - one sample t-test to test for differences in scores between static and ICT dynamic test scores -	No - hierarchical multiple regression used to see if DA and giftedness predict post-test scores - why not do a mixed factorial ANOVA?
Did the research report include not only inferential statistics but also effect size calculations?	Yes - partial eta squared reported	Yes	Yes - effect sizes reported for comparison of pre-test between groups
Was data available on attrition rates among intervention samples? Was severe overall attrition documented? If so, is attrition comparable across samples? Is overall attrition less than 30%?	No - three participants omitted due to incomplete data - no description of how this compared across conditions - final sample still contained 60 students in each condition despite randomised block design - unclear how this was achieved.	No data available	No data on attrition

Did the study provide not only internal consistency reliability but also test–retest reliability and interrater reliability (when appropriate) for outcome measures? Were data collectors and/or scorers blind to study conditions and equally (un)familiar to examinees across study conditions?	Yes - alpha measurements for pre and post-test for measurements and insertions provided - no reports of interrater reliability despite acknowledgement of scoring by both tester and first author	No	Yes, interrater reliability was reported
Were outcomes for capturing the intervention's effect measured beyond an immediate post-test?	No	No	No
Was evidence of the criterion-related validity and construct validity of the measures provided?	No	No	Yes -
Did the research team assess not only surface features of fidelity implementation (e.g., number of minutes allocated to the intervention or teacher/interventionist following procedures specified), but also examine quality of implementation?	No	Yes - fidelity of implementation was assured because of the digital nature of the task	No
Was any documentation of the nature of instruction or series provided in comparison conditions?	No	NA	No
Did the research report include actual audio or videotape excerpts that capture the nature of the intervention?	No	No	No
Were results presented in a clear, coherent fashion?	Yes	Yes	Yes
score/18	8	8 out of 15	5

Appendix 4

Scoring for Five Relevant Studies Under WoEA as Defined by the AERA Criteria

AERA criteria	**Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Craddock, C. F., & Hamlett, C. L. (2008).**	**Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Hamlett, C. L., & Seethaler, P. M. (2011).**	**Cho, E., Fuchs, L. S., Seethaler, P. M., Fuchs, D., & Compton, D. L. (2020).**	**Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L (2012).**	**Seethaler, P. M., Fuchs, L. S., Fuchs, D., & Compton, D. L. (2016).**
1) Problem formulation should provide a clear statement of the purpose and scope of the study	Yes - examining the predictive validity of a dynamic assessment of a novel maths task in competition with other factors using structural equation modelling	Yes - the purpose is to assess the utility of a two-stage screener for maths problems using maths dynamic assessment to inform secondary prevention in RTI prevention	Yes - problem is defined that EL learners are often overrepresented in special education as poor performance on tests of maths attainment, particularly in WPS may not be due to ability but rather language issues - a previous study has examined how MDA predicts later performance but language of administration may effect predictive validity	Yes - wish to examine the predictive validity of maths DA for 1st graders on maths achievement in word problem solving and calculation	Yes - does DA decrease false negatives in the identification of those who require secondary support under the RFI prevention framework and does this vary as a function of English language proficiency?

2) Reporting should make clear how the study is a contribution to knowledge and should include a review of the relevant scholarship that bears directly on the topic of the report.	Yes - review of previous studies examining predictive validity of DA - also outlines how DA is defined in the literature- alluding to index, interaction and type of task	Yes - outlines how static measures produce false positives for those identified for learning support	Yes - clear indication that some studies have examined the language of DA as a factor related to literacy, but few studies have examined how the language of DA effects the predictive validity of DA for maths ability in EL learners	Yes - review of three previous studies that explored DA as a predictor of maths achievement in school aged children - outlines Fuchs 2008 and outlines how the study adds to this body of knowledge	Yes - alludes to previous study (Seethaller, 2012) and outlines how this work is an extension to include ELP
3) The rationale for the conceptual, methodological, or theoretical orientation of the study should be described	No explicit reference	No explicit reference	No explicit reference	No explicit reference	No explicit reference
4) A rationale should be provided for the problem formulation as it relates to the groups studied	NA - 3rd graders - no condition - no rationale needed	NA - no relevance to particular group	Yes - an outline of the performance of English Learners in maths is provided as well as findings related to identification of this group for learning support as learning difficulties can arise for more reasons than in English proficient samples	Yes - rationale provided for studying 1st graders as within the context of education there is an emphasis on early intervention and the study explored whether this measure had predictive validity for later achievement	Yes - reference made to the representation of ELLs in special education and the difficulty in using translation for static standardised testing
5) Research reporting should	Yes, design and statistical analyses used to test the	Yes, design and statistical analyses used	Yes - the there is a clear link between the problem statement, research	Yes - the study was interested in assessing the predictive validity	Yes, the research aims to determine whether the predictive validity of DA for performance on WPS and CA differs as

follow a clear logic of inquiry	problem statement are succinctly outlined - SEM based on study by Day et al., 1997	to test the problem statement are succinctly outline	questions, design and data analysis employed	of MDA on both word problem solving and calculation while controlling for competing predictors such as numerical abilities and domain general factors - appropriate procedures were employed.	a function of ELP - use of regression is an appropriate statistical analysis
6) The units of study (sites, groups, participants, events, or other units) and the means through which they were selected should be adequately described and the means by which the sample was selected should be appropriate so that they reflect the named population of interest	Yes - participants recruited from a previous study and randomly selected from said study	Yes - reanalysis of data from Fuchs, 2008 study,	Yes - Els identified by schools as those qualified to receive EAL support based on scores of the English language development assessment	Yes	Yes - sample were recruited from 10 schools in a local district - the means by which they were recruited was not alluded to - LEP students were identified by teachers and assessed for maths ability using number sets test. English proficient students were chosen to be comparable with LEP children. school records indicate teachers misidentified 24 children as LEP who were actually proficient in English.
7) The collection of data or empirical materials should	Yes - all data was collected by trained university examiners in either group or individual sessions -	Yes - reanalysis of Fuchs, 2008 study	Yes - alluded to in the methods and procedures including a time scale for the project - alludes to the personnel that administered	Yes - timeline provided - administered by graduate students	Yes - timeline provided - tests administered by bilingual research assistants

be clearly described,	procedure for DA clearly described.		the English and Spanish versions of the DA		
8) The measurements should be clearly described,	No- reference was made to pilot work in construction of the DA measure but no reference to where this information can be obtained -	No- reference was made to pilot work in construction of the DA measure but no reference to where this information can be obtained –	No- reference was made to pilot work in construction of the DA measure but no reference to where this information can be obtained -	No- reference was made to pilot work in construction of the DA measure but no reference to where this information can be obtained -	No- reference was made to pilot work in construction of the DA measure but no reference to where this information can be obtained -
9) When measurement is entailed, reporting should describe data elements and organization in a specific and unambiguous way	Yes - descriptive statistics provided	Yes - descriptive statistics provided	Yes - descriptive statistics and correlations provided	Yes - correlations and descriptive statistics provided	Yes - means and SDs provided
10) The procedures used for analysis should be precisely and transparently described from the beginning of the study through presentation of the outcomes.	Yes	Yes - sensitivity, specificity, overall hit rate and area under the response operating curve used to contrast the two models	Yes - multi group path analysis used to indicate whether Spanish or English DA increased scores were higher while accounting for incoming maths ability and to see if models differentially predict maths outcome	No - for example one of the research questions was if the predictive validity of DA would differ for calculation and WPS but there was no indication of how this would be explored statistically	Yes -separate regression analyses conducted for LEP and non-LEP students to explain variance on CA and WPS

11) Analytic techniques should be described in sufficient de tail to permit understanding of how the data were analysed and the processes and assumptions underlying specific techniques	Yes - techniques outlined - data screened for outliers and tested for normality,	Yes	One way ANOVA used to test for differences on measures between groups prior to analysis - Tukeys test was employed to test for univariate outliers	No - does not address assumptions	No reference to assumptions underlying regression analysis
12) The analysis and presentation of the outcomes of the analysis should make clear how they support claims or conclusions drawn in the research.	Yes - as alluded to in the results and discussion sections - DA represents distinct variance from other factors according to confirmatory FA and SEM shows that DA as part of the base model is a better predictor of WP distal to instruction than three competing models.	Yes - data shows how the model which includes DA improves specificity of identification of those who need secondary level of support	Yes, the study interprets the data to show the significance of language dominance as a variable that interacts with language of DA administration to elucidate learning potential and decrease false positive for identification of those who require learning support	Not explicitly stated	Yes -
13) Analysis and interpretation should include information about any intended or unintended circumstances that	Yes - 150 students recruited, 122 had complete data sets - these students were comparable to the other participants in the cohort	Yes - 150 students recruited, 122 had complete data sets - these students were	Yes - 154 children moved during the course of testing - attrition was comparable across conditions	Yes - attrition rates alluded to	Yes - attrition rates alluded to

may have significant implications for interpretation of the outcomes, limit their applicability, or compromise their validity		comparable to the other participants in the cohort			
14) The presentation of conclusions should (a) provide a statement of how claims and interpretations address the research problem, question, or issue underlying the re search; (b) show how the conclusions connect to support, elaborate, or challenge conclusions in earlier scholarship; and (c) emphasize the theoretical, practical, or methodological	Yes, discussion alludes to the specific nature of the maths task as opposed to domain general DA, the scope of the competing variables and suggest DA offers predictive validity in relation to future learning in math	Yes - also includes a cost analysis for not utilising such an approach to reduce false positives	Yes - the study interprets the data to show the significance of language dominance as a variable that interacts with language of DA administration to elucidate learning potential and decrease false positive for identification of those who require learning support	Yes	Yes

implications of the study.					
15) Descriptive and inferential statistics should be provided for each of the statistical analyses that is essential to the interpretation of the results.	Yes -	Yes -	Yes -	Yes -	Yes -
16) Any considerations that are identified during the data that might compromise the validity of the statistical analyses or inferences should be reported.	Yes	Yes	Yes - tests for normality carried out and attrition rates referred to and comparison of attrition across groups	Yes	No reference to assumptions

17) For each of the statistical results that is critical to the logic of the design and analysis, there should be included:	yes	Yes - confidence intervals provided for AUC	Yes	Yes	Yes
18) Whether generalization is intended by the author or not, it is crucial to make clear the specifics of the participants, contexts, activities, data collections, and manipulations involved in the study.	Yes - makes reference to learning potential and the significance of a novel task to measure this latent construct in children in early years of schooling which is relevant to the design	Yes - make reference to the RTI prevention framework within which the study is embedded	Yes - groups well defined and sampled within the current study - study has good ecological validity with outcome measures of calculation and WPS	Yes	Yes
19) When generalization is intended, the	NA - no reference to generalisation	NA - no reference to generalisation	NA - no reference to generalisation	NA - no reference to generalisation	NA - no reference to generalisation

author should make clear the intended scope of generalization of the findings of the study					
Score /19	15/17	16/17	17/18	13/18	14/18

Appendix 5

WoEA for Case Study Data According to Criteria Set Out by Hyett et al. (2014)

Hyett et al., (2014) criteria	Moscardini & Moscardini, (2020)
1. Is this report easy to read?	Yes
2. Does it fit together, each sentence contributing to the whole?	Yes
3. Does this report have a conceptual structure (i.e., themes or issues)	No - more narrative in structure
4. Are its issues developed in a series and scholarly way?	No
5. Have quotations been used effectively?	Yes
6. Has the writer made sound assertions, neither over- nor under interpreting?	Yes
7. Are headings, figures, artefacts, appendices, indexes effectively used?	Yes
8. Was it edited well, then again with a last-minute polish?	Yes
9. Were sufficient raw data presented?	Yes
10. Is the nature of the intended audience apparent?	Yes - educational professionals
11. Does it appear that individuals were put at risk?	Participants were not put at risk
12. Is the case adequately defined?	No- indication that 11 out of the 17 children in the class were amongst the bottom 5% of all learners according to a standardised maths test administered by the local authority - little more information is offered in relation to Lara's general cognitive functioning/engagement/affective factors etc.
13. Is there a sense of story to the presentation?	Yes - data is well presented
14. Is the reader provided some vicarious experience?	Yes

15. Has adequate attention been paid to various contexts?	No - reference to the socio-economic factors within the area. Little reference to the curriculum, or local policy in relation to AEN
16. Were data sources well-chosen and in sufficient number?	Yes - one data source - the observations of an SET teacher - this is appropriate
17. Do observations and interpretations appear to have been triangulated?	No
18. Is the role and point of view of the researcher nicely apparent?	Yes - the role of the teacher is well outlined - particularly in relation to the understanding of Lara's conceptualisations
19. Is empathy shown for all sides?	Yes
20. is the case study particular	Yes
21.is the case study descriptive?	Yes
22. is the case study heuristic?	Yes
23. Was study design appropriate to methodology?	No - unclear the design and methodology employed
Score out of 23	17

Appendix 6

Outline of the Tiered System Used to Assign Scores for Included Studies in the Systematic Review under WoEB

WoEB was quantified based on how appropriate the design of the study was to answer the research question. For this purpose, a three-tiered scoring system was developed. It was decided that evidence that stemmed from one sample experimental studies that utilized a repeated measures design would provide the lowest quality evidence in relation to MDA because of the limitations associated with such designs such as the implications of practice effects and lack of control comparison. Medium quality evidence was obtained from quasi experimental group studies as well as case study and qualitative research. The latter are considered medium quality evidence because of the lack of generalisability. Finally, high quality evidence was obtained from randomised control trials and analytical cross-sectional designs that utilised regression or structural equation modelling to assess the predictive validity of MDA. Evidence from these studies were only categorised as high quality if there were sufficient competing predictor variables included in the design, otherwise this design was categorized as medium quality.

Appendix 7

Scoring for Each Study Under WoEC using Criteria Outlined by Haywood, (2012)

Study	Idiographic	Process-focused	Educability
Al Ahroub 2019	No	No	Yes
Al Ahroub, 2021	No	No	Yes
Brownell, Mellard and Deshner. 1993	No - Set number of prompts – hierarchically administered – graduated prompts	No	Yes
Bosma Stevenson, & Resing,2017	no	Yes	Yes
Cho, Fuchs., Seethaler, Fuchs, Compton, (2020).	No set level of prompts	No	Yes
Fuchs, Compton, Fuchs, Hollenbeck, Craddock, & Hamlett, (2008).	No – set level of prompts	No	Yes
Fuchs, Compton, Fuchs, Hollenbeck, Hamlett, & Seethaler, (2011).	No	No	Yes
Moscardini, & Moscardini, (2020).	Yes	Yes	Yes
Peltenburg, van den Heuvel-Panhuizen, & Robitzsch (2010).	No	Yes	Yes
Popa, & Pauc, (2015).	No	No	Yes
Seethaler, Fuchs, Fuchs, & Compton, (2012).	No	No	Yes
Seethaler, Fuchs, Fuchs, & Compton, (2016).	No	No	Yes
Wang (2014)	No	No	Yes
Wu, Kuo, & Wang, (2017).	No	Yes	Yes

Appendix 8

Principal Information Sheet

Principal Information Sheet

How does the Special Education Support Service framework for Maths Dynamic Assessment work in the Irish context to support a child exhibiting maths difficulties in primary school?

What is this Project about?

This project is aimed at understanding how Maths Dynamic Assessment can be used to support a child exhibiting maths difficulties in primary school. Dynamic assessment is a way of assessing a student that is more interactive than standardised testing and aims to paint a fuller picture of their strategies and understanding related to a specific task. The project involves the principal researcher conducting a maths dynamic assessment with a student and conducting feedback with teachers (Class and Special Education). Semi-structured interviews with the student and teachers will be conducted after the assessment has been completed.

Who is undertaking it?

The current research project is being undertaken by Seamus Cunniffe, a Trainee Educational Psychologist (TEP) as part of the Doctorate in Educational and Child Psychology (DECPsy) programme in Mary Immaculate College, Limerick. The project is supervised by DECPsy Joint Programme Leader, Dr Therese Brophy and Senior Lecturer in Education, Department of STEM education, Dr. John O'Shea.

Why is it being undertaken?

The Special Education Support Service released a framework which outlines how to conduct a Maths Dynamic Assessment in schools. To date there has been no research conducted assessing how useful this strategy may be. This project aims to conduct a maths dynamic

assessment in the school with a student who is having difficulty with maths and assess how useful the student and teachers found the process and how well it works.

What exactly is Involved?

Recruitment

If your school would be interested in taking part, teacher information sheets may be distributed to teachers of 2nd to 6th class. The class teacher or Special education teacher may have a student in mind that they think would benefit from a maths dynamic assessment. This student must be exhibiting difficulty with some element of the maths curriculum and must be proficient in the English language. The teacher would then distribute the parent information sheet and consent form to the families of this student. It would be emphasised to the family that participation is not mandatory, and the identity of the child has not yet been revealed to the researchers. If the family express interest in their child participating, then the signed parent and teacher consent forms must then be returned to the principal researcher. A child friendly information sheet and consent form will then be distributed to the student.

Process

The procedure is as follows. Initially the principal researcher will have a short consultation with the class teacher and/or SET to decide what areas of maths to focus the assessment on.

The assessment itself will happen across 3 visits to the school. It is preferrable if the assessment can be conducted in a special education room in a one-to-one setting and sessions should last 40 minutes. The sessions will be video recorded. Worksheets will be collected by the principal researcher and a research journal will be kept.

When the three sessions are complete the researcher will provide a written summary and have a final meeting with the class teacher and/or SET to discuss the student's understanding and progress.

The researcher will then conduct a semi-structured interview with the class teacher and special education teacher. This will gauge how useful they found the assessment process. A semi-structured interview will also be conducted with the student after the assessment sessions are complete. These interviews will be audio recorded.

Right to Withdraw

All schools and participants are free to withdraw at any stage of the process without consequence.

How will the information be stored and used?

The assessment sessions will be video recorded, semi-structured interviews with student and teachers will be audio recorded. The data obtained from the sessions will be stored securely in a password protected folder on a laptop. When this data is transcribed, it will be done so using pseudonyms so will not be identifiable. Once this data is transcribed all files will be deleted.

The researcher will also keep a research journal documenting the sessions, but this will also use pseudonyms.

Any materials in the form of worksheets or drawings will be stored in a locked filing cabinet along with the signed consent sheet. All anonymised data will be held indefinitely.

The thesis that will be written as a result of this project as a requirement for the fulfilment of the Doctorate programme will be made available in the Mary Immaculate College library and this document may include excerpts from interviews and sessions. The thesis may also be put forward for publication in a relevant scientific journal**. It should be noted however that all data that is part of the write up of the thesis will not be identifiable. Pseudonyms will be used so that for anyone reading the document it will not be possible to know which school, class, child, or teacher the data has come from.**

Contact Details

If you have any queries related to the project, please do not hesitate to get in touch.

Seamus Cunniffe

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Supervisors

Dr Therese Brophy

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Dr John O'Shea

Email: john.oshea@mic.ul.ie

If you have any concerns about this study and wish to contact an independent authority, you may contact:

Mary Collins, MIREC Administrator, Mary Immaculate College, Limerick

Telephone: 061-204980 E-mail: mirec@mic.ul.ie

Appendix 9

Principal Consent Form

Principal Consent Form

How does the Special Education Support Service framework for Maths Dynamic Assessment work in the Irish context to support a child exhibiting maths difficulties in primary school?

	Please tick
I have read the attached information sheet that entails details of the proposed research project.	
I understand that the school's participation in this study is optional.	
I understand that I have the right to withdraw my consent for the school to participate in the study.	
I understand that dynamic assessment sessions will be video recorded to aid in analysis.	
I understand that a semi-structured interview will be audio recorded with teachers and children.	
I understand the video and audio recordings will be transcribed using pseudonyms so the data will not be identifiable, and once this has been done all recordings (video and audio) will be deleted.	
I have contact details for the primary researcher of the current study and I am aware I can contact them for any further information required.	
I am satisfied that procedures are in place to ensure the data provided as part of the research project will be protected and anonymised.	
I am aware that data obtained as part of this research will be written up as part of a doctoral thesis which will be available in Mary Immaculate College Library and may be put forward for publication in a scientific journal.	

I hereby consent to participation in the following research project – “An Exploration of the implementation of the SESS framework for Maths DA with pupils experiencing maths difficulties in the Irish education system using Yin's case study methodology”

Principal name ____

Signature: ____

School: _____________________________________

Date: ____________________

Appendix 10

Teacher Information Sheet

Teacher Information Sheet

How does the Special Education Support Service framework for Maths Dynamic Assessment work in the Irish context to support a child exhibiting maths difficulties in primary school?

What is this Project about?

This project is aimed at understanding how Maths Dynamic Assessment can be used to support a child exhibiting maths difficulties in primary school. Dynamic assessment is a way of assessing a student that is more interactive than standardised testing and aims to paint a fuller picture of their strategies and understanding related to a specific task. The project involves the principal researcher conducting a maths dynamic assessment with a student and conducting feedback with teachers (Class and Special Education). Semi-structured interviews with the student and teachers will be conducted after the assessment has been completed.

Who is undertaking it?

The current research project is being undertaken by Seamus Cunniffe, a Trainee Educational Psychologist (TEP) as part of the Doctorate in Educational and Child Psychology (DECPsy) programme in Mary Immaculate College, Limerick. The project is supervised by DECPsy Joint Programme Leader, Dr Therese Brophy and Senior Lecturer in Education, Department of STEM education, Dr. John O'Shea.

Why is it being undertaken?

The Special Education Support Service released a framework which outlines how to conduct a Maths Dynamic Assessment in schools. To date there has been no research conducted assessing how useful this strategy may be. This project aims to conduct a maths dynamic

assessment in the school with a student who is having difficulty with maths and assess how useful the student and teachers found the process and how well it works.

What exactly is Involved?

Recruitment

If you think there is a student that may benefit from a maths dynamic assessment who is having difficulty with maths you can make contact with their parents and offer them the opportunity to take part. The child should be proficient in the English language and not currently be being assessed by a psychologist from NEPS. It should be emphasised to the family that participation is not mandatory although this will be expressed in the information sheet. If they express interest, you can provide them with the attached information sheet and consent form for parents. A child friendly information sheet and consent form will be provided to the student.

Process

If you, the family and student agree to take part in the study you can return the signed consent forms to the principal researcher. Following this the principal researcher will have a short consultation with you to decide what areas of maths to focus the assessment on.

The assessment itself will happen across 3 visits to the school. It is preferrable if the assessment can be conducted in a special education room in a one-to-one setting and sessions should last 40 minutes.

When the three sessions are complete the researcher will provide you with a written summary and have a final meeting with you to discuss the student's understanding and progress.

The researcher will then conduct a semi-structured interview with the class teacher and special education teacher. This will gauge how useful you found the assessment process. A follow up interview will be conducted a number of weeks later to assess progress. A semi-structured interview will also be conducted with the student after the assessment sessions are complete.

Right to Withdraw

All schools and participants are free to withdraw at any stage of the process without consequence.

How will the information be stored and used?

Maths dynamic assessment sessions will be video recorded, and semi-structured interviews with student and teachers will be audio recorded. The data obtained from the sessions will be stored securely in a password protected folder on a laptop. When this data is transcribed, it will be done so using pseudonyms so will not be identifiable. Once this data is transcribed all files will be deleted.

The researcher will also keep a research journal documenting the sessions but this will also use pseudonyms.

Any materials in the form of worksheets or drawings will be stored in a locked filing cabinet along with the signed consent sheet. All anonymised data will be held indefinitely.

The thesis that will be written as a result of this project as a requirement for the fulfilment of the Doctorate programme will be made available in the Mary Immaculate College library and this document may include excerpts from interviews and sessions. The thesis may also be put forward for publication in a relevant scientific journal**. It should be noted however that all data that is part of the write up of the thesis will not be identifiable. Pseudonyms will be used so that for anyone reading the document it will not be possible to know which school, class, child, or teacher the data has come from.**

Contact Details

If you have any queries related to the project, please do not hesitate to get in touch.

Seamus Cunniffe

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Supervisors

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Dr John O'Shea

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If you have any concerns about this study and wish to contact an independent authority, you may contact:

Mary Collins, MIREC Administrator, Mary Immaculate College, Limerick

Telephone: 061-204980 E-mail: mirec@mic.ul.ie

Appendix 11

Teacher Consent Form

Teacher Consent Form

How does the Special Education Support Service framework for Maths Dynamic Assessment work in the Irish context to support a child exhibiting maths difficulties in primary school?

	Please tick
I have read the attached information sheet that entails details of the proposed research project.	
I understand that participation in this study is optional	
I understand that choosing to not consent to participating in the study will not be penalised.	
I understand maths dynamic assessment sessions with the student will be video recorded to aid analysis	
I understand that semi-structured interviews will be audio recorded	
I understand the video and audio recordings will be transcribed using pseudonyms and all recordings will be subsequently deleted.	
I understand that I have the right to withdraw my consent at any time and will not be penalised for doing so.	
I have contact details for the primary researcher of the current study and I am aware I can contact them for any further information required.	
I understand my right to anonymity, and I am satisfied that the procedures in place to ensure the data provided as part of the research project will be protected.	
I am aware that data obtained as part of this research will be written up as part of a doctoral thesis which will be available in Mary Immaculate College Library and may be put forward for publication in a scientific journal.	

I hereby consent to participation in the following research project – "An Exploration of the implementation of the SESS framework for Maths DA with pupils experiencing maths difficulties in the Irish education system using Yin's case study methodology"

Teacher ____

Signature: ____

Date: ______________________

Appendix 12

Parent Information Letter

Parent Information Letter

How does the Special Education Support Service framework for Maths Dynamic Assessment work in the Irish context to support a child exhibiting maths difficulties in primary school?

What is this Project about?

This project is aimed at understanding how Maths Dynamic Assessment can be used to support a child exhibiting maths difficulties in primary school. Dynamic assessment is a way of assessing a student that is more interactive than standardised testing and aims to paint a fuller picture of their strategies and understanding related to a specific task. The project involves the principal researcher conducting a maths dynamic assessment with a student and conducting feedback with teachers (Class and Special Education). Semi-structured interviews with the student and teachers will be conducted after the assessment has been completed.

Who is undertaking it?

The current research project is being undertaken by Seamus Cunniffe, a Trainee Educational Psychologist (TEP) as part of the Doctorate in Educational and Child Psychology (DECPsy) programme in Mary Immaculate College, Limerick. The project is supervised by DECPsy Joint Programme Leader, Dr Therese Brophy and Senior Lecturer in Education, Department of STEM education, Dr. John O'Shea.

Why is it being undertaken?

The Special Education Support Service released a framework which outlines how to conduct a Maths Dynamic Assessment in schools. To date there has been no research conducted assessing how useful this strategy may be. This project aims to conduct a maths dynamic

assessment in the school with a student who is having difficulty with maths and assess how useful the student and teachers found the process and how well it works.

What exactly is Involved?

If you would like for your child to take part in the study, you can return the signed consent form to the school. Ideally the assessment sessions will take place during maths lessons.

An overview of the assessment process:

- The process will consist of 3 visits to the school.
- These sessions will preferably take place in a one-to-one setting.
- sessions should last around 40 minutes.

What will happen during the process?

- The principal researcher will meet with your child to discuss their interests to help with the assessment sessions.
- The principal researcher will meet with class and special education teachers (if relevant) to decide what areas of maths to focus on.
- Your child will be given some maths tasks to do independently.
- Your child and the principal researcher will jointly discuss and make sense of the tasks using a range of materials to test their understanding.

What happens after the Assessment sessions?

- The primary researcher will feed back to the teachers after each session.
- Semi-structured interviews will be held with teachers to see if they found the assessment useful
- A semi-structured interview will be held with your child to see how useful they found the assessment and if they enjoyed it.

Does my child have to take part?

No. Participation in this study is entirely voluntary. By choosing not to partake in this study your child will not be penalised or miss out in any way. Your child will receive any support deemed appropriate by the school regardless of whether they participate in the study or not**.**

Right to Withdraw

All schools and participants are free to withdraw at any stage of the process without consequence.

How will the information be stored and used?

The assessment sessions will be video recorded, and semi-structured interviews with student and teachers will be audio recorded. The data obtained from the sessions will be stored securely in a password protected folder on a laptop. When this data is transcribed, it will be done so using pseudonyms so will not be identifiable. Once this data is transcribed the files will be deleted.

The researcher will also keep a research journal documenting the sessions, but this will also use pseudonyms.

Any materials in the form of worksheets or drawings will be stored in a locked filing cabinet along with the signed consent sheet. All anonymised data will be held indefinitely.

The thesis that will be written as a result of this project as a requirement for the fulfilment of the Doctorate programme will be made available in the Mary Immaculate College library and this document may include excerpts from interviews and sessions. The thesis may also be put forward for publication in a relevant scientific journal**. It should be noted however that all data that is part of the write up of the thesis will not be identifiable. Pseudonyms will be used so that for anyone reading the document it will not be possible to know which school, class, child, or teacher the data has come from.**

Contact Details

If you have any queries related to the project, please do not hesitate to get in touch.

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Telephone: 061-204980 E-mail: mirec@mic.ul.ie

Appendix 13

Parent Consent Form

Parental Consent Form

How does the Special Education Support Service framework for Maths Dynamic Assessment work in the Irish context to support a child exhibiting maths difficulties in primary school?

	Please tick
I have read the attached information sheet that entails details of the proposed research project.	
I understand that participation in this study is optional.	
I understand that by choosing to not consent to my child participating in the study, my child will not be penalised, and they will still receive any support deemed appropriate by the school.	
I understand that I have the right to withdraw my consent for my child to participate at any time and will not be penalised for doing so.	
I understand that maths dynamic assessment sessions will be video recorded to aid analysis	
I understand that a semi-structured interview will be audio recorded with my child	
I understand that video and audio recordings will be transcribed using pseudonyms so the data will not be identifiable and once this is complete all recordings (video and audio) will be deleted.	
I have contact details for the primary researcher of the current study and I am aware I can contact them for any further information required.	
I understand my right to anonymity, and my child's right to anonymity and I am satisfied that the procedures in place to ensure the data provided as part of the research project will be protected.	

I am aware that data obtained as part of this research will be written up as part of a doctoral thesis which will be available in Mary Immaculate College Library and may be put forward for publication in a scientific journal.	

I hereby consent to participation in the following research project – "An Exploration of the implementation of the SESS framework for Maths DA with pupils experiencing maths difficulties in the Irish education system using Yin's case study methodology"

Parent name ____

Signature: ____

Child's name: ____

School:____

Date: ______________________

Appendix 14

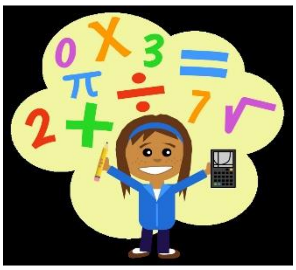
Child Information Sheet

Child Information Sheet

Hello, my name is Seamus!

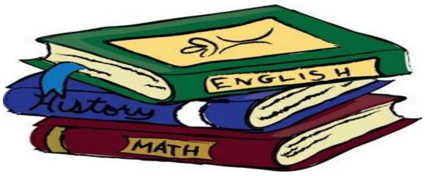
I am writing a paper about how children in primary school learn maths and how we can help them

I am visiting your school today because I would like to do some work with you and find out how you do maths and how teachers can help.



I will come back 2 more times to do more work with you.

Today, I will ask you questions about what you like to do and your favourite subjects.



Then I will ask you to do some maths questions.

Then we will talk about some maths questions together using counters, whiteboards, markers and other things.

When we are working together, I will video record what we are doing so I can write it down later and I don't forget!

After we are done I will talk to your teachers so they know how to help you.

The last thing I will do is talk to you about our work together so we can decide if we can help other children by doing the same thing. I will record this too so I can write it down later!

When it is all done I will write my paper about how to help children with maths, and I will write down some things that you say. People can read this paper but I won't put your name in it so no one will know it is you.

You don't have to work with me. And if you start the work and you really don't like it you can stop whenever you want.

Appendix 15

Child Assent Form

Child Assent Form

Name:	Tick (✓)	
	This is ok ! 	I don’t think this is ok 
Are you happy to do some maths work with me for 3 lessons?		
Are you happy for me to ask you questions about the work we do together when we are finished?		
Are you happy for me to video record the work we do together?		
Is it ok if I write about some of the maths lessons and some of the things you say in my paper?		

Appendix 16

Detailed Outline of Recruitment Process and Inclusion Criteria for the Current study

The recruitment process began with informing primary school teachers at a teacher training event in a rural region in Ireland about the aims and scope of the project. Information sheets and consent forms for principals, teachers and parents were distributed at this event to those teachers that expressed interest (See appendices 8-13). Teachers were informed of the inclusion criteria for the study and were instructed to distribute information sheets to their principal and subsequently to discuss the possibility of participation with parents of a student they thought may benefit from mathematics dynamic assessment. If parents were interested in their child partaking in the research an information sheet was then sent to the school to be distributed to them by the teacher.

Inclusion criteria for participation in the study were as follows:

- The young person must be having pervasive difficulties in maths i.e. difficulties with a number of strands within the curriculum as indicated by consultation with the class teacher.
- Difficulties must have persisted for a period of at least 6 months.
- The student must currently be receiving additional educational support at the level of “support for some” or “support for few” of the continuum of support, (NEPS, 2007) for maths difficulties.

Exclusion criteria for participation includes:

- If the child has significant EAL needs i.e. below grade B1 on the test of language proficiency in listening, (Integrate Ireland Language and Training, 2003).

- If the child is currently being assessed and receiving support from an educational psychologist for learning needs.
- If the child has a diagnosis of an intellectual disability.

Once parents expressed interest, teachers were asked to make a phone call to the researcher to anonymously discuss the student in question in relation to their maths achievement and how they meet the inclusion criteria. The first three proposed students that met inclusion criteria were selected as the pilot and two case studies.

Appendix 17

Initial Interview with Student **-** *Adapted from Allsopp and colleagues', (2008) Mathematics Student interest Inventory*

Things I Like to Do on My Own –

Special Hobbies I Have

Things I Like to Learn About

Things I Like to Do With My Friends

Fun Things My Family Does

What do you like about school?

What are your favourite subjects?

What are your least favourite subjects?

Do you like maths?

Appendix 18

Initial Teacher Consultation Template

What is this student like? Can you describe them in a general way?

What is this student like in the classroom?

How is this student engaging with the maths curriculum? Is their work differentiated? Are they receiving support?

What are the particular strands of the maths curriculum that you have noticed that this student requires support in?

Appendix 19

Teacher Semi-Structured Interview Schedule

What are your experiences of teaching maths in the Irish primary education context?

How do you currently identify a student exhibiting maths difficulties?

How do you currently support a student with maths difficulties in the mainstream/special education classroom?

What kind of support do you expect from educational psychologists to support a student with maths difficulties?

Did the maths dynamic assessment process fit with your expectations for support from an educational psychologist?

Did you find the maths dynamic assessment useful?

How did it enhance your understanding of the conceptualisations of the young person?

Do you think it is an appropriate method to assess a child exhibiting maths difficulties?

How will it inform teaching strategies/intervention and assessment moving forward?

Appendix 20

Student Semi-Structured Interview Schedule

Can you remember all of the things we did during our maths sessions?

Did you like the maths sessions? - If so what did you like/not like about them?

How is it different from the way you learn maths in the mainstream class?

Is there anything that you learned that you think will help you?

Appendix 21

Dynamic Assessment UK Checklist of General Learning Principles. Source: Learning Resources-https://www.dynamicassessmentuk.com/

Cognitive

Learning Principles	Y / N Ch.	Comment
Communication Is the child communicating their answers in a clear and coherent manner?		
Comparative Behaviour Is the child comparing objects, noticing what is similar / different?		
Efficiency Is the child working at a reasonable pace rather than taking excessive time to ensure the answer is correct?		
Exploratory Behaviour Is the child searching for solutions rather than setting on the first one that comes to mind?		
Justification of response Is the child able to justify their responses i.e. explain how they solved the problem?		
Memory Is the child able to remember information/strategies sufficiently, in order to complete tasks?		
Nature of response Is the child answering with meaning rather than guessing randomly?		
Planning Is the child using a plan or strategy to solve the problem?		
Problem Definition Is the child showing that they understand the nature of the task?		
Recognition Is the child able to recognise when answers are incorrect?		
Reflectiveness Is the child pausing to reflect on their answers?		
Spatial Orientation Is the child aware of positioning, left and right and co-ordination?		
Transfer of learning Is the child able to transfer the learning from one problem to the next?		

Vocabulary Is the child labelling the information using the appropriate vocabulary?		

Affective

Learning principles	Y / N Ch.	Comment
Accessible to Assistance? Is the child seeking help, prompting assistance and willing to become involved in a collaborative exchange?		
Attention Is the child able to sustain attention for a significant period of time?		
Concentration Is the child able to focus and remain concentrated on the task?		
Confidence in correct responses? Is the child answering with conviction, sticking to their answers when challenged?		
Flexibility Is the child flexible in their use of strategies and in their general way of working, e.g. are they able to change how they approach a problem?		
Frustration Tolerance Is the child attempting problems/tasks regardless of perceived difficulty, e.g. are they keen to try?		
Motivation Is the child keen to perform well? Presentation Is the child relaxed/comfortable?		
Task Perseverance Is the child continuing to work on the task despite encountering difficulties?		
Vitality and Awareness Is the child eager, full of energy and alert?		

Appendix 22

Mediated Learning Experiences Checklist. Source: Learning resources: https://www.dynamicassessmentuk.com/

Mediated Learning Principle	Comment
Implicit help Is the mediator only having to give small hints, clues and prompts in order to improve performance?	
Explicit help Is the mediator having to give detailed feedback/assistance including explicit discussion of strategies in order to improve performance?	
Engaging Is the mediator trying to engage the child in a reciprocal interaction?	
Making sense Is the mediator promoting meaningfulness in the task?	
Bridging Is the mediator making links to previous or future experiences, e.g. what happens in the classroom?	
Encouraging Is the mediator giving frequent, enthusiastic praise and encouragement in a way that provides valuable feedback to the child?	
Self-regulation Is the mediator trying to ensure the child slows down, reflects and takes his/her time?	
Sharing Is the mediator interacting in a way that communicates that he/she is on the child's side, that they are working together as a team?	
Independence Is the mediator taking a step back at appropriate points to allow the child to take over when working on tasks?	
Planning Is the mediator encouraging planning: showing what to do before beginning to solve the task and how to set achievable goals?	
Monitoring Is the mediator ensuring that the child is checking his/her answers?	
Explaining Is the mediator asking for explanations, guiding the child to justify their answers?	
Verbalising Is the mediator encouraging the child to talk aloud when doing the tasks in order to highlight their thinking?	
Scaffolding Is the mediator gradually building up skills, giving less and less help until the child takes over responsibility for learning?	
Challenging Is the mediator ensuring that tasks are challenging, without overwhelming the child?	

Change Is the mediator highlighting new skills that have been learned and showing the progress that has been made?	
Positive outlook Is the mediator maintaining a positive outlook at all times despite difficulties?	

Appendix 23

Codebook used to code data for themes related to mediated learning experiences

Mediated Learning Principle	Further clarification	Example
Implicit help Is the mediator only having to give small hints, clues and prompts in order to improve performance?	Is the researcher pointing to some important elements of the task without explicitly outlining how to complete	If the student is having difficulty completing a 2 digit addition computation the researcher highlights one important component such as carrying the one.
Explicit help Is the mediator having to give detailed feedback/assistance including explicit discussion of strategies in order to improve performance?	Is the researcher modelling exact solutions for the student with no or little input from the student (distinguished from scaffolding as the student has some level of input)	If the student is doing a 2 digit computation the researcher completes an item without any input from the child
Engaging Is the mediator trying to engage the child in a reciprocal interaction?	The researcher makes the material engaging for the student by interacting reciprocally, incorporating their interests and being playful	The researcher plays a number game to assess the child's understanding of number
Making sense Is the mediator promoting meaningfulness in the task?	Is the researcher using the language of the student to make sense of the problem situation. Is the researcher using the students interests or presenting the problem in different modalities (written, symbolic, concrete materials etc.)	If the student has difficulty with a word problem the researcher presents it using concrete materials or drawings
Encouraging Is the mediator giving frequent, enthusiastic praise and encouragement in a way that provides valuable feedback to the child?	Is the researcher giving enthusiastic praise to the child in response to improved engagement, communication, understanding etc.	When a child completes a task the researcher says "well done" or "good job"

Self-regulation Is the mediator trying to ensure the child slows down, reflects and takes his/her time?	Is the researcher supporting the child to regulate themselves when they get excited, upset, lose motivation etc.	When a student gets upset and frustrated the researcher reassures the child and redirects them to the task in a supportive way
Sharing Is the mediator interacting in a way that communicates that he/she is on the child's side, that they are working together as a team?	Does the researcher engage the child in tasks that are shared and completed jointly? Does the researcher communicate in a way that suggests they are on the same team (use of the term "we" etc.)	The researcher says "now we are going to play a game, I'll take the first turn"
Independence Is the mediator taking a step back at appropriate points to allow the child to take over when working on tasks?	Does the researcher encourage the child to be autonomous and display knowledge in their own way	The researcher asks the child to complete an addition task using any medium they prefer e.g. concrete materials, symbolic numerals etc.
Planning Is the mediator encouraging planning: showing what to do before beginning to solve the task and how to set achievable goals?	Does the researcher ask the child for their plan prior to beginning the task?	The researcher explains a task then asks the student to stop by saying "tell me your plan before you start"
Monitoring Is the mediator ensuring that the child is checking his/her answers?	Is the researcher encouraging the child to check answers by repeating wrong answers, encouraging different methods to check answers etc.	The student may answer 4+3=8, the researcher repeats this and asks the student to check their answer on a number line
Explaining Is the mediator asking for explanations, guiding the child to justify their answers?	Once the child provides an answer is the researcher encouraging the child to explain the process they used in gaining the answer?	After completion of a task the researcher says "that's good can you tell me how you got that answer?"
Verbalising Is the mediator encouraging the child to talk aloud when doing the tasks in order to highlight their thinking?	As the child is engaged with a task is the researcher encouraging them to verbalise their actions and thought processes? (distinguished from	As a child is manipulating concrete materials the researcher says "can you tell me what you are doing there?"

	explaining and planning as this is during the task. Planning is before and explaining is after)	
Scaffolding Is the mediator gradually building up skills, giving less and less help until the child takes over responsibility for learning?	Is the researcher structuring the task and giving some degree of support while still engaging the child and requiring them to have input at some stage within the process?	The researcher begins to carry out an addition computation using concrete materials by making the two addends, the student then completes the task
Challenging Is the mediator ensuring that tasks are challenging, without overwhelming the child?	Does the researcher purposely change the parameters of a task to make it more difficult for a child e.g. if they are reliant on one method of doing a sum . Does the child explicitly acknowledge that the task is challenging?	The researcher notices the child is using a number line to complete sums and so takes it away.

Appendix 24

Codebook to identify elements of the theoretical pattern of Structural Cognitive Modifiability

Construct	Elaboration	Example
Does not do/misconceptualisation – the child does not show an ability to perform a skill or exhibits a level of misunderstanding	The child has clear distinguishable difficulties in the use of an identified skill or understanding of a construct which they would be expected to be able to do in line with their developmental age and exposure to appropriate learning experiences	A child in fourth class uses one word answers and under developed verbal responses to communicate their thinking
Mediated Learning Experiences – already identified and coded in previous thematic analysis		
Structural cognitive modifiability – there is clear evidence the student shows reconceptualization or has developed skills to a higher level than previously identified	The child shows a clear progression either in understanding of a maths construct or an ability to use a skill which must be related to an identified lack of ability previously. This improved ability must be predicated by at least one mediated learning experience that is identified following evidence of misconception/lack of ability and plausibly accounts for this improvement.	Triangulated evidence from teacher consultation and video transcripts suggest that the child does not communicate effectively. The child is encouraged to verbalise and explain their answers. Appropriate language is modelled. The child is given alternative means to represent problems which make them more accessible and easier to understand. There is evidence that the child then uses more effective communication.

Appendix 25

Codebook to identify elements of the theoretical pattern of the Zone of Proximal Development

Construct	Elaboration	Example
Does not do – child does not show an ability to use the skill effectively with or without support	The child has clear distinguishable difficulties in the use of an identified skill or understanding of a construct which they would be expected to be able to do in line with their developmental age and exposure to appropriate learning experiences	A child in fourth class uses one word answers and under developed verbal responses to communicate their thinking
Does with help/support – the child shows an ability to perform the skill with help	The child shows an improved understanding or improved ability to perform a skill when supported appropriately by the researcher – there must be clear evidence of understanding or ability to perform the skill and not merely respond to the ques of the researcher or use trial and error supported by the researcher	A child in 3rd class uses guessing and trial and error to complete a sum. By the researcher not responding to guesses and supporting the child to be reflective and purposeful the child uses an appropriate strategy to complete the sum.
Does independently – the child shows an ability to perform the skill without help	There is clear evidence that the child has shown an understanding of the concept or shown an ability to perform the skill that is independent of the support of the researcher	A child in 5th class is asked to complete a 2 digit operation using concrete materials to display understanding of place value, and completes the task appropriately and independently.

Appendix 26

Detailed Description of the Intercoder Reliability Analysis for Mediated Learning Experiences, Structural Cognitive Modifiability and the Zone of Proximal Development for Pilot Data

A subset of the total coding of the data was subjected to a review by a second coder. The data subjected to this review was from the pilot data and was focused on the mediated learning experiences, and identified patterns of SCM and the ZoPD. This process involved the second reviewer receiving the codebooks produced by the researcher and independently reviewing the codes already identified under each theme. Reviewers then met and discussed disagreements.

Traditionally intercoder agreement would be measured by the second coder receiving the codebook from the researcher and reviewing an excerpt of the transcribed raw data, with identified codes then compared between coders (Guest et al., 2012). This was deemed to be beyond the scope of what was possible in the current investigation for two reasons:

1) Mediated learning experience codes were difficult and significantly time consuming to identify within transcribed video excerpts. Identified codes were not a singular quote but often constituted an extensive interaction between the researcher and the pupil. 12 different types of mediated learning experiences were identified within the total transcribed pilot data set which would have amounted to an arduous workload for the second rater to produce any worthwhile intercoder analysis.

2) Identified codes of the 12 identified themes of mediated learning experiences were well dispersed throughout the data set and across multiple sources of data including the videoed flexible interviews and pupil semi-structured interviews. To select an excerpt that

was substantial enough to include the majority of themes yet brief enough so as not to burden the second rater with an extensively time-consuming and complex task proved exceedingly difficult.

A further critical discussion related to the interrater reliability analysis is presented in the critical review and impact statement.

The intercoder reliability analysis elucidated that codes under the themes of “encouraging”, “making sense” and “monitoring” were the most reliably identified. “Explicit help” was the least reliably identified with a number of original codes determined to fit more accurately with the description of the theme “scaffolding”. Analysis of codes under the theme “sharing” resulted in an agreement between raters that a slight modification was needed to the codebook to include excerpts that indicated the researcher was learning from the pupil and not unilaterally directing the session. This change is reflected in the codebook at Appendix 23.

Intercoder reliability analysis for identified patterns of SCM and ZoPD resulted in the removal of two codes identified as evidence of structural cognitive modifiability as it was determined these codes did not provide enough objective evidence of improved understanding according to the definitions outlined in the codebook. Also removed was another code that was inaccurately identified as evidence of the child not exhibiting skills in producing meaningful responses. All other codes were agreed between coders.

The above evaluation provides evidence that codes could be objectively identified according to the codebooks produced for the current analysis. Collaboration with a second coder resulted in minor changes to identified codes and descriptions within the codebooks. Initial coding was completed by the researcher on the 19th February 2024. Intercoder reliability analysis was completed on the 25th of March. Following this analysis identified codes were reviewed by the principal researcher for the two other case studies with recommendations from the intercoder reliability analysis.

Appendix 27

Thematic Analysis of Domain General and Domain Specific Learning Functions for Pilot Data (Peter). Definitions are Derived from Checklists at "Learning resources": https://www.dynamicassessmentuk.com. See Appendix 21.

Thematic Analysis of Affective Learning Functions.

Attention Is the child able to sustain attention for a significant period of time?
Concentration Is the child able to focus and remain concentrated on the task?

Excerpt	Source
but Peter does not maintain attention for extended periods and the quality of his work can suffer as a result.	Teacher consultation
The SET suggests Peter really benefits from one to one work and that his difficulties in maths are more pronounced when he is in the mainstream classroom, but he works very well with her.	Teacher consultation
S: Now, so I'm going to start today and we're going to do a few sums P: Okay. S: And so you did a few of these for me last week. And I just want you to.. P: *gets up and walks around the table to get a pencil*	Flexible interview
S: Okay. Let's try another one. Can you do this one for me, Peter? (Sum is 7+6) So, sit here for me. (Peter was standing leaning over the table)	Flexible interview
P: Because this.. it's still... 1 more than this (points to previous sum) (stands up and drops pencil)	Flexible interview
S: What? It's in the shape of a candy cane. (units are in a curved shape) S: It's in the shape of what? P: In the shape of a candy cane.	Flexible interview

S: In the shape of a candy cane. Is it?	
P: Yeah.	
And I counted over.	
(starts counting again)	
P: Let me get this.	Flexible interview
This is 14? (referring to the previous sum)	
P: Where did you get this rubber? (grabbing eraser for whiteboard)	
S: I got that in the shop.	
S: Good job, exactly. It's 22.	Flexible interview
P: Is this thing magnetic? (putting eraser on whiteboard)	
S: It is magnetic, yeah, that's right.	
P: Magnetic.	
S: So I don't even have to scramble them up and start from the beginning.	Flexible interview
I can just count from here. Six, seven, eight, nine.	
It's pretty cool, isn't it?	
P: Yeah.	
S: Yeah.	
P: *starts singing and nodding his head*	
S: So, I'm going to draw this for you.	Flexible interview
So, if we have nine dots, okay?	
(Draws 9 dots, 1,2,3,4,5,6,7,8,9)	
P: I want this colour.	
Seamus, what colour was in here? (pointing to empty space in box of markers)	
S: I'm not sure, you know.	
Well, it could have been a black or a blue marker.	
S: Okay.	Flexible interview
So, if we have nine all together, Peter.	
P: Zero isn't a number. Why is it called a number?	

Why is a W called a W? Its actually a V, a double V.

S: You’re getting into really good questions now.
P: Look. (starts to draw a W)
It'll be rounded like this.
Because it is really a W.

P: (writing 12) It's only a one and a two. Flexible interview
It's not… its that easy.
S: It's good work, though.
P: What are those? (pointing to something in the distance)
S: You're getting distracted are ya?
P: No, I'm just wondering what those are.

P: Wait, that's six. Flexible interview
That's supposed to be six.
S: Oh, OK.
P: I actually have a big Christmas tree.
That's hanged up.
I have like a Christmas tree that's fully decorated.
I have two.
One that my sister made. And one that my mum made.

P: (draws 6 circles on the other side of the plus)
S: Well done. So you have two. Flexible interview
P: I can understand sounds.
S: You understand sounds?
P:Yeah.
S: Good.
P: That's an ow. (Bangs marker on whiteboard)
S: That's an ow?
P: Yeah.

In sign language

S: So OK, so we have two over here. And four over here. So now we have one, two, plus one, two, three, four. (counting the units in the different sets) That equals six. What do you think of that? P: Is there a scratch on my head? S: I don't think so. P: I feel like a scratch.	Flexible interview
S: So you can use these over here (drawn squares), or you can use the blocks (units). So... First one, is going to be... P: I want the sponge. I'd like to have more than... A little more than the sponge. I think this would be good for cleaning, S: for cleaning? P: it looks like a sponge,	Flexible interview
S:yeah 4 plus 1, exactly so I'm just going to put it over here, (Moving one unit away) and it's going to be.. (drawing the circles either side of the plus sign on the whiteboard) P: (grabbing the unit and moving it around) it's running away all of a sudden, look, look, this is this, leaving the party, S: need it back though, so do you see how we can do it by drawing the line here (at the drawing of the squares), or by moving the blocks here (the units)	Flexible interview
S: so can you tell me what this sum is, P: (grabbing two extra units) and these two came out of nowhere and say, hey, can I join the party? S: no, we have to keep that 5, good man	Flexible interview

P: (starts doodling on whiteboard) S: what's that? Is that you? Okay. You ready? I'm going to challenge you now.	Flexible interview
P: Do you want your tens too? Here's your tens S: No, I'm okay for tens. Watch this, now. Sit in your chair for me. (Peter is standing leaning over the table)	Flexible interview
P: * grabs tens and units box* S: No, I don't need any more. We have our five. That's all we need. Okay, so. We need you to write them out for me.	Flexible interview
S: so we started with 5 P: *goes to grab 5 more units* S: No, no. Weve got five already. You've got to use these ones P: Just incase.. They fling off the whiteboard and *mimes the units flying off the table*	Flexible interview
S: But I want you to try to be clever and figure out how this works. So we only need these five. (units) Why don't you take them in your hand? P: They look kind of like a Minecraft pickaxe. S: Is that what they are? A Minecraft pickaxe. Is that the way that Minecraft works? P: *takes other units and puts them in a formation on the whiteboard* Minecraft! S: So it looks like a pickaxe, like that? P: Yeah, Minecraft pickaxe.	Flexible interview
P: We can put the things over here. (pointing to the other side of the partition) S: Yes. We can.	Flexible interview

P: *tries to put copy on the empty side of the whiteboard*
S: Oh, no because we need that space. So I'll show you in a second, right?
So five minus zero.
P: (starts grabbing the box with units in)
S: (takes them away from him)

S: Start with five. One leaves the party. Flexible interview
P: (flicks the unit away with his pencil)
S: Careful now.

S: Now, I'm going to take this whiteboard away from you. It's distracting you, isn't it? Flexible interview
Oh, say bye-bye to the circles.
P: I love it.
S: I know.

S: And look, if we use our number square, Flexible interview
what does it look like?
So start at one
Jump up two to three.
Two to five.
P: Look at how many lines I've drawn.

Motivation Is the child keen to perform well?
Frustration Tolerance Is the child attempting problems/tasks regardless of perceived difficulty, e.g. are they keen to try?

Excerpt	Source
S: Okay. Peter what was the most difficult thing or the thing that you liked least about what we did ? P: the very hard questions, because get past them.. was making me upset. S: Yeah, at the end you got a little bit upset. Did Yeah. P: Yeah. S: Yeah. That was because you were trying so hard. Though wasn't it?. P: Yeah. S: Yeah. Good Man, I was really proud of you. And you did great work. And do you know what? You pushed yourself really hard, which is really good. So well done on that. P: Yeah.	Student SSI
S: and what was it that I was doing that made it so difficult and made you upset? P: couldn’t figure out the answers. S: ok	Student SSI
S: and do you think.. you know how I asked you to explain your answers and get you to explain it to me. Do you think that worked really well at the start when you knew it? And then when it was a little bit more difficult It was more frustrating? P: Yeah, S: yeah.	Student SSI
S: That's still zero plus six, isn't it?	Flexible interview

P: Yeah.
S: So we need a new way. Because ..
P: I’m out of ideas (a little bit upset)
S: Oh, OK. I'll go with this. (puts 6 units back together)
I'll go with this one.

S: But I'm going to do a different one now. Flexible interview
I'm going to do the five game
It's the same game.
Is this a really tricky game for you Peter?
P: (putting his hand on his forehead and sighing deeply)
It's too tricky.
S: Is it?
P: Yeah.
S: Do you want me to give you loads of help?
We can do it together.
P: I don't really like this game.
S: Oh, you don't like it?
P: No.
S: Oh, okay. That's fine.
P: It's too hard.
S: It's tricky, isn't it?
P: Yeah.
S: Yeah. That's okay. Don't worry about it.
Will we do it nice and slow together.

S: No, so you're adding two. So it's three, four, five, isn't it? Flexible interview
P: Five.
S: Yeah, so you're adding two.
P: This makes no sense. I don’t like this (gets upset puts head down)
S: Oh, you find that hard?
P: Yeah.

S: Okay,
well you got the first one really well, remember?

P: Done with this? Flexible interview
S: Yeah, done altogether.
P: everything?
S:. Yeah, all finished.
You did a great job.
P: (getting upset, puts hand on forehead)

S: Look at this. Flexible interview
Four.
Five.
Six.
You OK?
P: (shakes head and drops marker)
S: What's going on?
P: You’re breaking my brain
S: OK, do you want to take a break? Is it too much?
P: Yeah.
S: awh Thanks for telling me because I didn't know. I was trying to hard with you. Was I?

S: Okay, so we're going to do a little bit of maths today. Flexible interview
P: Yay!
S: Yeah, you really like maths, don't you?
P:Yeah.
S: Good man.

Flexible interview
S: Good job. I'm going to test you again.
P: Yippee.
S: Because I think you're just making these look too easy. That was a really clever strategy. I like that.

Now, you've done a great job. P: Yay! S: Good job. Now, let's have a look here. If I said to you, what is 11 plus 10? (writing it in copy) P: 11 plus 10, that's... Um... 21.	Flexible interview
S: OK. (opens figure it out 1 textbook to page 5) P: Ooohhh.. I like this. Test yourself, two.? I want to test myself. S: OK, so what do you have to do here?	Flexible interview
S: I'm going to get you to do something a little bit different for me. I'm going to go back over to the whiteboard because I know the whiteboard is your favourite. (takes whiteboard) P: Yay!	Flexible interview
S: Okay. Can you do this first one for me? So, as well as that, right, we have all of these things that might be able to help us.	Flexible interview
P: Yay! S: Hundred square. You know the hundred square, don't you? P: Yeah.	Flexible interview
P: No. S: And then we have the whiteboard. We'll probably do a little bit on the whiteboard later on. P: Yay! S: You love the whiteboard, don't you? P: Yeah.	Flexible interview

S: Good man. Okay, start off with this one for me.	
S: it might not be? I'm going to take this off you now. (number square) I'm going to start taking all these bits off you. And I'll give you, if you want that. (whiteboard) P: Yay! S: Okay. So you've got these markers. You have these fellas, haven't you? (units) P: Yay, units. S: Yeah. P: My little units.	Flexible interview

Thematic Analysis of Cognitive Learning Functions

Communication Is the child communicating their answers in a clear and coherent manner?

Excerpt	Source
S: First thing Peter can you remember about our sessions and all that we did? P: Well, some of them I forgot. But some, like half of it was gone. And the other half stayed S: Okay, so tell me about the half that stayed. What are the bits that you can remember? P: Well, basically, I explained the basically, the brothers of like the plus and the minus, where the minus is like a bad guy. And the Plus is a good guy.	Student SSI

S: That's right. Yeah, that's very true. Can you tell me this? What was your favourite thing about what we did together? … P: Ummm.. we were doing like hard questions and minus questions too.. the plus... And I explained this. at First I realized, what was I doing? I might as well just teach this because I just knew S: That's so clever. Did you feel like you had to explain it and nearly teach it? P: I would say kind of.. Yeah, I wanted to teach it to you but you have to keep it a secret.	Student SSI
S: So is that one of the favourite things that you did? Because you were able to talk about it and nearly teach it? And that was a good way of learning? P: Yeah, S: okay. Good. P: teach it to you because You really needed it. And you'd be able to do it.	Student SSI
S: Okay. And I want you to talk me through how you're doing each sum. P: How I'm doing my sum? Counting! S: Yeah, I want to learn from you. P: Counting. You just count S: Okay, so is that how you do them? You count them? P: Yeah.	Flexible interview
P: alright. Okay. So look this is how you do it. (puts pencil on number line at the top of the page) You put your pencil on the number and then you count alongside the pencil where its going. You don't count 9,10,11 (pencil started on 8 – the first addend) You count 1,2,3,4,5,6,7,8 (moving pencil from 8 to 16)	Flexible interview

That’s how you get your answer!
Its 16!

P: 9 plus 3? (reading the next sum) Flexible
S: We’ll do one more. 9 plus 3. interview
P: Is 12.
I didn't even have to count for him.
S: You didn't have to count?
P:It's so clear.
S: How did you do that to?
P: Because brain. (pointing to his head with his pencil)

S: Can you explain to me how you got that? It's so clever.
P: Because.
Nine plus one is ten, and if you count two more, then you have three.. and that is my answer

P: 9+7? I know that answer. 17 Flexible
S: What? How did you know that? interview
P: 17.
S: What?
How did you get that so quick? You didn't even count them up.
P: Because this.. it's still... 1 more than this (points to previous sum)
S: Good job. Now, let's have a look here. Flexible
If I said to you, what is 11 plus interview
10? (writing it in copy)
P: 11 plus 10, that's...
Um...
21.
S: 21?
How did you get that?
…
P: Because 10 plus 10 is 20.

S: That's right, yeah.
P: And if I had one more...21
P: So. Then they reunite. Flexible
S: they reunite? Interesting. interview
What reunites?
P: The five and four.
S: Oh, the five and four. They reunite.
P: Like the four went missing, so the nine and five. It's from a minus. And then the 5 got his best friend back
..
P: Yeah. He found the 9 that he created with four, then he's gone missing.
So he made 4.
P: Same answer. Flexible
S: What? Same answer? interview
P: Yeah.
S: What?
P: They just switched it around. (next sum in copy was the reverse of the previous sum 8+4)
S: So it's the same answer?
P: Mm-hmm.
That's what you do.
If there's like an answer below an answer, and it's the exact same answer, it can be confusing.
…
P: That's how I got it. It's switching.
They're trying to trick your brain. Don't let it happen.
P: No I just count on the higher number. Flexible
That's all. interview
S: Oh, you count on from the higher number?
P: Yeah. From the higher number. Then I count the lower number.
S: Good job. Try this one for me.
Next one shows 5 cars split into 3 and 2, no numbers only 3 spaces provided underneath) Flexible
P: *writes 3* interview
Then write a two. *writes 2*
Then I'm going to get my answer for you.

Hold on. That’s 5.
S: How did you get that? You didn't even count them.
P: the answer,, It just appeared out of nowhere in my head.
S: It just appeared out of nowhere in your head, you just knew that one?.
P: Yeah.

S: Okay. Flexible interview
But I want you to think about the game.
How are you going to make as many sixes as you can? What's going to be your plan?
P: Well, I think you're going to see.
S: I’m going to see, okay?

S: Oh, seventeen minus eight. Okay. Flexible interview
Okay, so I want you to write it out here for me. (in the copy)
And how would you do that? Because you explained...
P: Nine.
..
S: How did you get that?
P: Nine. I knew it all the time. (points to his head with pencil)
S: You just knew it?
And did you have to do any counting? Or did you have to do anything?
P: Anything? No.

S: Can you do this next one for me? (14-5) Flexible interview
How are you getting these Peter?
P: no its not 11.
9 again.
S: You're doing a lot of thinking there. What are you thinking while you're doing that?
P: I whisper stuff to myself and then I just...

S: What's it that you're whispering? Are you keeping it to yourself, keeping it a secret?
P: *nods

S: Eleven minus four
P: hmm seven! Seven?

Flexible interview

S: Okay.
I'd love to know how you're doing these.
So clever. You're getting them all right. How are you doing?
P: I'm just...
S: Hmm?
P: Just thinking.
S: Just thinking?

Flexible interview

(15-6)
P: 11?
S: How do you know?
P: Book. (points to textbook in my hand)
I don't see it, but.
S: you've no number line.
So how have you got this?
(peter points to number square)
Did you check your number square?
Check your number square. See how you got it.
S: So now we have five.
P: So these guys are having a party. He left the party. (referring to the units on the first side and grabbing the one unit on the other side)

Flexible interview

S: Yeah So put it over here. (the unit on the other side of the partition)
P: He's like, see you guys later.
S: (writing the sum in the copy) Minus what? Five minus?
P: One.

S: Because he left the party, didn't he?
P: Yeah.
S: And how many's left of the party?
P: four
S: Hey! Good man.
Job done.
S: Okay, what about our next one? Flexible interview
P: Next one... The guy says, hey, I'm leaving the party now. I've had enough. I'm tired.
I'm going to bed, I'm leaving.
Then he joins these. (moves another unit across)
S: How many did we start with, Peter?
P: five
S: How many left the party now?
P: Four.
S: How many is left of the party?
P: One. (writes sum out in copy)Look at that perfect one.
S: What's our last one? Flexible interview
P: Nobody's left the party. Come on, leave. Come with me too (grabs the last unit and moves it across) (starts writing sum)
so five
S: mmhmm
P: Minus zero.

Flexible interview

P: So they went to go use the restroom.
He's like, guys, I'm going to go use the restroom.
S: Yeah.
P: I'm going to go use the restroom.
S: How many is at the party now, Peter?
P: Five.
S: Are you ready for your mind to be blown?
P: Yeah.

P: Basically, pluses and minuses are brothers.. . but They don't get along very well. S: They're kind of opposite brothers, are they?	Flexible interview
P: Like this is a plus. Adding on S: Yeah. P: So once you have three and two, they're like separated from each other. (with 3 units on one side of the partitioned whiteboard and 2 on the other side) The plus helps it break through and make a number together. S: Oh, good man. P: Minus keeps them locked up.	Flexible interview
P: Yeah, because look, just pretend these guys are over here. (takes 3 units and puts them on one side of the board) and These guys are over here. (takes other 3 units and puts them on the other side) S: Yeah. P: And the minus comes along and it's like, oh, a little guy's locked up. You got to never see each other again. S: I like that. Yeah, that's very true. they can't see each other again. And what does the plus do? P: The plus helps them. The plus helps them go back together,	Flexible interview

Nature of response Is the child answering with meaning rather than guessing randomly?

Excerpt	Source
S: there's nine all together, isn't there? (circling around all 9 dots) P: Yeah. S: Okay, so nine. Now, if we took away the five, (pointing to the segment with 5) how many would we be left with? P: The five? S: Yeah. P: We take away one dot? S: If we took away these five. (circling around the segment with 5) P: Oh, so it's zero.	Flexible interview
S: Yeah, I was a cheeky chicken. I'm going to be cheeky chicken again.. Okay. (takes textbook and number line away) And now I'm going to ask you to start writing in the squares. (gives him squared copy) And I'm going to ask you to write by 15. First one, 15. (Peter writes 15) Good job. Minus. Six. Equals. (Peter writes sum in copy) P: 11? S: This time, we have 16. Minus. Eight. (writes in copy) P: Nine. Nine. S: Now you're rushing through a bit. How did you get that one?	Flexible interview

P: Five. Flexible interview
S: Minus? How many left the party?
P: Two.
S: Equals? How many's left?
P: Equals... Four??
S: How many's left? P: Three.
S: You sure? Can you show me?
P: Two.
So it's two?
looks for reassurance
long pause
I don't know if it is or it's not.

S: (writes, 1,3,5,7,9) Flexible interview
Oh, can you crack that code for me? Give me the next two when to crack the code.
P: Twelve.
S: So explain what you're thinking. Why are you thinking twelve?
P: It's twelve. Closest to nine..

Recognition Is the child able to recognise when answers are incorrect?
Reflectiveness Is the child pausing to reflect on their answers?

Excerpt	Source
P: *writes 8+4=16* S: 8 plus 4 equals..? P: 16. S: So can you say that for me? P: 8 plus 4 equals 16. S: Is that right? 8 plus 4 equals 16. Does that look okay? P: *nods	Flexible interview
P: 1, 2, 3, 4, 5, 6, 7 (Has two piles, of 7 and 8) S: Good job. So how are you going to do the sum now? P: I'm counting them all. S: Okay, let me see you. P: (starts counting each block) 1, 2, 3, 4, 5, 6, 7,8,9,10,11,12, 13, 14,16 S: 16 is it? P: Yeah.	Flexible interview
P: 9+7? I know that answer. 17 S: What? How did you know that? P: 17. S: What? How did you get that so quick? You didn't even count them up. P: Because this.. it's still... 1 more than this (points to previous sum)	Flexible interview
P: You have to get nine, (counts 9 blocks but miscounts and gets 10) and then take away five from it. (counts 5 blocks) How many do you have left?	Flexible interview

S: (counting the remaining blocks)
we have 1,2,3,4,5
P: Yeah.
S:Is that right?
Is nine minus five five?
P: Yeah

Flexible interview
I know. (writes 2+4)
S: two plus four equals..?
P: Fifteen?
S: Fifteen. You think?
P: Yeah.
S: yeah so do you think it's much harder for you to do the blocks than it is to do the number line? Flexible
P: sometimes I have to double check interview
S: ok and do you think the blocks can help you double check?
P: mmm yeah

P: 9 again Flexible
S: How sure are you that that's right? interview
P: I don't know.
S: Are you positive or are you thinking maybe it's right?
P: Maybe.
S: Okay. Let's try the next one.
S: Ready for my next one? Flexible
P: Yeah. interview
S: Just write it out here for me. (in the sums copy)
This time, we have 16.
Minus.
Eight. (writes in copy)
P: Nine.

Ready? (switches up so its black, green, 2 red) Okay. Off you go. P: (puts black, 2 green, 2 red) S: ok Is that right? P: Yeah. S: So, we had (pointing to the pattern) black, green, two red. We had black, green, two red. now We've got black. (pointing to what Peter put down) P: Green. S: Two green, though. P: (changes to one green) S: There you go.	Flexible interview

Thematic Analysis of **D**omain **S**pecific **L**earning **F**unctions

Sets and Operations

Evidence	**Source**
It was noted he scored particularly low on number, algebra, word problems, and computation. The class teacher suggests this is consistent with her observations and suggests he has particular difficulties with number bonds.	Teacher consultation
Peter had difficulty completing subtraction computations even with the aid of a number line on the page as he only got 7/10 correct. Peter had great difficulty accurately completing three single digit addition computations without the aid of the number line. From this it can be seen that Peter may be continuing to develop his concept and understanding of numeracy. He appears to be reliant on a counting strategy using a number line to complete computations and when he has to do subtraction computations this strategy isn't as efficient as he can not as readily check his answers. This is owing to the fact that he is familiar with the order of numbers in the forwards direction but less familiar with the order moving back. His performance on basic computations without a number line to help him is further evidence of this difficulty.	Error pattern analysis

S: First thing Peter can you remember about our sessions and all that we did? Student SSI
P: Well, some of them I forgot. But some, like half of it was gone. And the other half stayed
S: Okay, so tell me about the half that stayed. What are the bits that you can remember?
P: Well, basically, I explained the basically, the brothers of like the plus and the minus, where the minus is like a bad guy. And the Plus is a good guy.

S: we did we had a math book and any thing else? Student SSI
P: um, sheets.. you would like covered a book and..
S: that's right.
P: And try guess the answer, I would try and guess the answer but every time I needed my number square there.

P: You also like tried to make it like pretty hard for me. Was still like acing them. Student SSI
S: Okay, you're absolutely right. How was I trying to make it hard? What was I doing?
P: Like you're .. you were.. You took the number square and you took.. I think you took the markers..
S: Yeah. Yeah. So
P: I had to count with little cubey things

S: Okay, and so when you come out of the classroom Peter and you do your work with Miss Heaney.. Is the maths that we did very different to that or is it kind of the same? P: kind of different.. sometimes it has like a number line on top of like the sheet page. So makes a bit easy. it goes up to 20 normally. Not like 100 S: so it's a bit easier with me or a bit easier with Miss Heaney? P: it's a bit easier with My 100 square I use it all the time. I use it all the time. If There's no like number thingy on top (number line on top of the page)	Student SSI
P: and an answer switched around doesn't change anything. S: Yes, P: its still the exact same thing S: you're talking about with the.. when you're adding two numbers if you swapped them around, they're still the same? That was really clever. P: they're literally the same numbers. What do you expect?	Student SSI

S: do you remember we did some work? And we played the six game and we drew six dots, and then we had to split them up? How did you find that? Was that difficult? Student SSI
P: It was a bit difficult because I had to find like different answers with the minus and it was a bit hard.
S: You found that hard?
P: I found it hard I would say
S: Can you tell me do you prefer to use the number line for most of your sums
P: Most of them? Yeah.

S: Okay. And I want you to talk me through how you're doing each sum. Flexible interview
P: How I'm doing my sum?
Counting!
S: Yeah, I want to learn from you.
P: Counting. You just count

P: 9 plus 3? (reading the next sum) Flexible interview
S: We'll do one more. 9 plus 3.
P: Is 12.

But, what if I did this Peter and I took your number line? Flexible interview
So what would you do?
P: I would count but I couldn't see the number..

P: 8+7? Flexible interview
S: Will you do that for me?
and I'll steal your number line so you can't have it.
What are you going to do?

P: 9+7? I know that answer. 17 Flexible interview
S: What? How did you know that?

P: 17.

P: 12+5? Flexible interview
S: mmhmm
P: I need some more of these (grabbing units)
S: So can you check this one for me? (referring to 8+7) Flexible interview
P: This one?
S: Yeah.
Check on the number line.
S: Good job. Now, let's have a look here. Flexible interview
If I said to you, what is 11 plus
10? (writing it in copy)
P: 11 plus 10, that's...
Um...
21.

S: So we have nine minus five. Flexible interview
P: Nine minus.
S: Is there any way we can get this answer really quickly? (Just did 4+5=9)

P: six plus two? Flexible interview
S: Mm-hmm.
P: that’s Eight.
S: Eight.

S: Let's try this one. (2+4) Flexible interview
P: It's the exact same answer. Look. (referring to the previous two sums that both equal 5)

P: Look at this. Flexible interview
Three. (draws three circles on one side of the plus)
And another three (draws another three circles on other side of the plus)
S: Good job.
P: And then that's six.
S: Wow. Okay. So you've one done.
Good job.

Can you split them up with a line in a different way? Flexible interview
P: Yeah.
S: Show me.
P: (draws a line down the middle segmenting the circles into 3 and 3)
S: So what would that be?
P: Three.
S: Three plus?
P:Two.
S: No.
What is that? (pointing to the other side)
P: Three plus three.
S: Yeah. So you have to do it in a different way.

S: OK. Flexible interview
Can you write this one for me?
P: Yeah.
S: What is it?
P: So it goes like that.
Two at the top.
Two at the bottom.
Then down here. (draws 6 circles on the other side of the plus on the whiteboard)

S: That's still zero plus six, isn't it?
P: Yeah.
S: So we need a new way. Because ..
P: I’m out of ideas (a little bit upset)

S: ok, so we might have to do the 1 plus 4 afterwards, so what can we do first, is there another way to make 5, Flexible interview
P: yeah,
S: how can we break these up?

S: can I ask you something? Flexible interview
P: yeah
S: do you find it harder when you have to do it with the blocks than when you have to do it with the number?
P: I get confused
S: do you?
P: but sometimes I make up some mistakes
S: oh in what way?
P: in counting
S: yeah so do you think it's much harder for you to do the blocks than it is to do the number line? Flexible interview
P: sometimes I have to double check
S: ok and do you think the blocks can help you double check?
P: mmm yeah
S: Oh, seventeen minus eight. Okay. Flexible interview
Okay, so I want you to write it out here for me. (in the copy)
And how would you do that? Because you explained...
P: Nine.

Eleven minus four — Flexible interview
P: hmm seven! Seven?
S: Okay.
I'd love to know how you're doing these.
So clever. You're getting them all right. How are you doing?
P: I’m just..
….
S: Okay.
P: That 11's right here. Count back 4, that’s 7

Flexible interview
S:This time, we have 16.
Minus.
Eight. (writes in copy)
P: Nine.
Nine.

S: Now, what do you think we should do next? How are we going to figure out another sum that makes five? — Flexible interview
P: (moves one unit to the other side, leaving four and one)

S: Now, let's see. My turn next, okay? (moves another unit over the partition to leave 3+2) — Flexible interview
Oh.
What does that say?
P: Three plus two.
S: Okay.

S: Okay. — Flexible interview
Now.
How are we going to figure out our next one? Our next minus one to make five?
P: (moves two units across the partition to leave 3 and 2)
S: Okay. What's the sum?
Can you write it out for me?

P: (pauses and shakes his head)
S: It's tricky, isn't it?
P: Yeah.

S: So now we have five. Flexible interview
P: So these guys are having a party. He left the party. (referring to the units on the first side and grabbing the one unit on the other side)
S: Yeah So put it over here. (the unit on the other side of the partition)
P: He's like, see you guys later.

S: So we started with five. How many left the party? Flexible interview
P: Two.
S: Who's left at the party?
P: Three.
S: You sure?
P: Yes!
S: Okay, write it down for me.
P: (writes the answer in sum copy) Three.

S: So what's our next one? Flexible interview
P: Break them up. (takes another unit and brings it to the other side)
Three left.
S: So we started with?
P: High five.
S: High five, yeah. So you can write it down for me. Five.
P: Minus two.
S: How many left?
P: Three.
S: Equals? How many are left at the party
P: two (writes sum down in copy)

S: What's our last one? Flexible interview
P: Nobody's left the party. Come on, leave. Come with me too (grabs the last unit and moves it across)
(starts writing sum)
so five
S: mmhmm
P: Minus zero.
S: We started with five, Peter.
And how many left the party?
P: five
S: Yeah, and how many is left of the party now?
P: Zero.
S: Equals?
P: Zero.

We started with five. Flexible interview
Okay, so we have five at the party. (five units back on one side of the partitioned whiteboard)
And two leave. (puts two on other side)
P: Three.
S: So then you have... You start with five.
How many went away?
P: Two.
S: And how many is left of the party?
P: Three.
S: (writes 5-2+3 in copy)
Now, this time. So we have five minus two equals three.
Now, if we have three at the party.
And we add two to back to the party. (moves 2 units back to the first side)
They come back to the party. How many is here?

P: So they went to go use the restroom. Flexible interview
He's like, guys, I'm going to go use the restroom.
S: Yeah.
P: I'm going to go use the restroom.
S: How many is at the party now, Peter?
P: Five.
S: Are you ready for your mind to be blown?
P: Yeah. S: So you have five.
And then two leave.
And you're ending up with three. (showing 5-2=3 in copy)
And the same way.
You start with the three. And then the two come back. (showing 3+2=5)
And you're ending back with the?
P: Five.
S: So do you see how they work the other way around?
. Flexible interview
P: Basically, pluses and minuses are brothers.. . but They don't get along very well.
S: They're kind of opposite brothers, are they?
That's a really cool way of thinking about it

P: Like this is a plus. Adding on Flexible interview
S: Yeah.
P: So once you have three and two, they're like separated from each other. (with 3 units on one side of the partitioned whiteboard and 2 on the other side)
The plus helps it break through and make a number together.
S: Oh, good man.
P: Minus keeps them locked up.
S: Wow.
Minus keeps them locked up. That's really clever. I love that way of describing it.

S: Now, So you've got the opposite brother, haven't you? Flexible interview
Because, I'll explain it to you again, watch. So we start with six. (pointing to 6 in the sum copy and 6 units on one

side of the board)
Minus one. (points to copy and moves one unit to other side of the board)
P: Minus comes along.
S: Exactly, and how many are left at the party?
P: Five.
S: And then we find the opposite brother, which is the addition.
And then we've got five plus one when he comes back to the party. (shows sum in copy and shows the unit moving back to the other side of the partition)
P: When he takes down the wall.
S: Yeah, equals.
P: That makes . six again.
S: Six again, exactly. Good man.
So we have to start with four that are left at the party. Flexible interview
Now what's the next bit?
P: we add.. plus comes along..
And he brings two, so two.
S: Yeah, he brings them back. Exactly.
How much does that equal?
P: Six. Yay!
S: Hey, good man.
S: So watch this, again.. Flexible interview
So we'll just have one party, okay? (puts 4 back on the first side and moves one unit across the partition on the whiteboard)
S: So four minus
P: one
S: equals what? How many is left at the party?
P: equals 3..
S: Can you find the opposite brother to bring them back together?
What's the opposite brother to bring them back together?
P: Uh-huh.
S: what is it?
P: three.. plus one

S: Equals what?
P: equals.. (puts one unit back with the other 3)
four
S: Yeah, well done. Great job.
Watch this. Flexible interview
Four is what we're starting with at the party. (moving the 4 units back across the partition)
P: Yeah.
S: So now two are leaving the party. (moving 2 across the partition)
P: Oh. by minus.
S: By minus and then....
So, how many is left at the party?
P: Um, how many? Two.
S: Two. (writing 4-2=2 in copy)
Can you bring them back together for me, Peter?
P: (brings two units back across the partition) Four.
S: So what is it, two?
P: Two plus Two.
Two equals four.
S: Yeah.
So do you see the brothers? (showing maths copy with two sums written)
Four minus two equals two.
But then you bring them back. Bring the two back and you end up with the four
What you had at the start!
P: Yeah.
S: Do you like that?
That's really clever.
P: I made it myself.

Appendix 28

Thematic Analysis of Mediated Learning Experiences for Pilot Data. Definitions derived from Checklists at "Learning resources": https://www.dynamicassessmentuk.com. See Appendix 22.

Challenging Is the mediator ensuring that tasks are challenging, without overwhelming the child?

Excerpt	Source
S: Good man. We did. P: You also like tried to make it like pretty hard for me. Was still like acing them. S: Okay, you're absolutely right. How was I trying to make it hard? What was I doing? P: Like you're .. you were.. You took the number square and you took.. I think you took the markers.. S: Yeah. Yeah. So P: I had to count with little cubey things	Student SSI
S: No, but can I be cheeky? Because I want to learn a little bit more about you. I think you're really clever in what you're doing Like you told me when you start on a number and then you count on to the next number. That's a really good strategy. But, what if I did this Peter and I took your number line? So what would you do?	Flexible interview transcript
P: Four plus eight? S: Yeah. P: number line? S: OK, so I'm going to take the number line away. Can you come up with any other way to do it for me? +	Flexible interview transcript
How about this? We'll play a game, Peter. P: What game? S: (draws 6 circles in the corner of the board) P: Six. S: Now I have a rule for this game. P: What is it? S:The rule is that you can't write down any numbers. So I can't write down this, or this, or this, or	Flexible interview transcript

this, or this, or this (writing down symbolic numerals) +	
You don't have your number line. P: Cheeky. S: Do you know what I'm doing? Yes, that is cheeky. So you'll have to come up with another way to do it. P: dots S: ok we can do that. Now. .That's a good plan. Think about this one. P: One dot. Two dots. Three dots. (drawing dots on whiteboard) +	Flexible interview transcript
S: No. Something completely different. Watch this. I'm going to split this in half. Like this? Like this. (draws line down the middle of the whiteboard) P: What are you doing? S: Okay. So. Now, look. Give me that. (tens) Good man. Watch this. How many do we have? (holding 5 units) P: (counts 5) Five. S: Five. So, we have five all together. I'm going to try to figure out how many sums I can make with my five. Okay?	Flexible interview transcript

Encouraging Is the mediator giving frequent, enthusiastic praise and encouragement in a way that provides valuable feedback to the child?

Excerpt	**Source**
*writes 9+3 12 S: Did you forget the equals? P: *writes in the equals* No. *rubs out to make space* You gotta go. S: Thank you for explaining that to me. That's so clever.	Flexible interview transcript
S: Because it's one more than the one you already did. Is that right? P: *nods S: So it has to be one more than the last answer. That's so clever. You didn't even need to count from there. Good job.	Flexible interview transcript
P: Okay. I'll count them in in 12. And then count up 5. S: That's a good plan.	Flexible interview transcript
P: Because 10 plus 10 is 20. S: That's right, yeah. P: And if I had one more...21	Flexible interview transcript

S: Good job, well done.	
P: Yeah. S: Do you ever... You were really good at explaining how you think, I really like that.	Flexible interview transcript
P: Do I have to write them in dots? S: Mm-hmm. P:I have to write dots. S: So before you start, tell me what you're thinking. I love the way you think. It's really interesting	Flexible interview transcript
P: (draws one circle and five circles on whiteboard) S: There you go. Good job. high five. (high five)	Flexible interview transcript
P: 2 (draws 2 blocks on other side of the plus), S: hey, give me a proper high five this time, well done. you were telling me before that you found this really tricky, but you did an absolutely brilliant job there, didn't you?	Flexible interview transcript
S: Where's your equal sign? P: Oh. (puts in equals sign) S: That's alright. Great job. That's good. That was a really good plan. I like it.	Flexible interview transcript
So five minus three equals? P: Two. S:Two. Good man. High Five. Good job	Flexible interview transcript
S: And how many's left of the party? P: four S: Hey! Good man. Job done.	Flexible interview transcript

Engaging Is the mediator trying to engage the child in a reciprocal interaction?

Excerpt	Source
How about this? We'll play a game, Peter. P: What game?	Flexible interview transcript
S: (draws 6 circles in the corner of the board) P: Six. S: Now I have a rule for this game. P: What is it? S:The rule is that you can't write down any numbers. So I can't write down this, or this, or this, or	Flexible interview transcript

this, or this, or this (writing down symbolic numerals)

Explaining Is the mediator asking for explanations, guiding the child to justify their answers?

Excerpt	**Source**
P: Our favourite. My favourite thing about the S: about the maths P: Oh, you mean? The maths.. S: Yeah, about the maths we were doing. P: Ummm.. we were doing like hard questions and minus questions too.. the plus... And I explained this. at First I realized, what was I doing? I might as well just teach this because I just knew S: That's so clever. Did you feel like you had to explain it and nearly teach it? P: I would say kind of.. Yeah, I wanted to teach it to you but you have to keep it a secret. S: Okay, I'll keep that between me and you.	Student SSI
S: Yeah. Because it was really clever the way you explained it, but I really, really liked it. Good, man. So is that one of the favourite things that you did? Because you were able to talk about it and nearly teach it? And that was a good way of learning? P: Yeah, S: okay. Good. P: teach it to you because You really needed it. And you'd be able to do it. S: Well, I'm not going to do it for that one. Because it's only between me and you. But it's then.. It's something I could teach other children, isn't it? Yeah,	Student SSI
P: Is 12. I didn't even have to count for him. S: You didn't have to count? P:It's so clear. S: How did you do that to? P: Because brain. (pointing to his head with his pencil) S: Can you explain to me how you got that? It's	Flexible interview transcript

so clever.
P: Because.
Nine plus one is ten, and if you count two more, then you have three.. and that is my answer

P: 9+7? I know that answer. 17 S: What? How did you know that? P: 17. S: What? How did you get that so quick? You didn't even count them up. P: Because this.. it's still... 1 more than this (points to previous sum)	Flexible interview transcript
S: 21? How did you get that? Oh, you forgot your equals. (Peter wrote the sum without the equals sign) P: Easy. Easy enough. S: did you think that was? P: I said the answer was 21. S: How did you get it? P: Because 10 plus 10 is 20. S: That's right, yeah. P: And if I had one more...21	Flexible interview transcript
S:. So you have to do 4+5. So can you say if you were explaining it to someone younger than you, and you had to show them with the blocks? Can you show me? P: I always have to try to teach my younger brother, but he says it's a higher number than the answer.	Flexible interview transcript
P: No I just count on the higher number. That's all. S: Oh, you count on from the higher number? P: Yeah. From the higher number. Then I count the lower number. S: Good job. Try this one for me.	Flexible interview transcript
P: Then I'm going to get my answer for you. Hold on. That’s 5. S: How did you get that? You didn't even count them. P: the answer,, It just appeared out of nowhere in my head.	Flexible interview transcript

S: It just appeared out of nowhere in your head, you just knew that one?.
P: Yeah.

P: Nine.
Flexible interview transcript
S: How did you get that?
P: Nine. I knew it all the time. (points to his head with pencil)
S: You just knew it?
And did you have to do any counting? Or did you have to do anything?
P: Anything? No.
S: You just knew it? Straight away?
P: Yeah.

S: Can you do this next one for me? (14-5)
Flexible interview transcript
How are you getting these Peter?

S: You're doing a lot of thinking there. What are you thinking while you're doing that?
Flexible interview transcript
P: I whisper stuff to myself and then I just...
S: What's it that you're whispering?
S: Okay.
Flexible interview transcript
I'd love to know how you're doing these.
So clever. You're getting them all right. How are you doing?
P: I'm just...
And are you doing it where... Are you starting at the big number and then counting back?
Flexible interview transcript
P: Yeah.
S: So how would that look?
P: Basically.
S: How would that look? So if you stared at that 11, what were you doing there?
Were you moving back in your head back to the number?
P: No, I was just staring at the numberline.
S: What's a pattern?
Flexible interview transcript
P: Give me two of those markers and colours.
S: Do you want two colours?
There you go. You show me.

S: And what's the next number?
Flexible interview transcript
P: Five.
S: Now, how did you get that?
P: What?
S: How did you get five?
Do you know how you got it?
S: (writes, 1,3,5,7,9)
Flexible interview transcript
Oh, can you crack that code for me? Give me

the next two when to crack the code.
P: Twelve.
S: So explain what you're thinking. Why are you thinking twelve?
P: It's twelve. Closest to nine.

Explicit help Is the mediator having to give detailed feedback/assistance including explicit discussion of strategies in order to improve performance?

Excerpt	**Source**
S: But for now, is there anything that you learned when we were doing our maths that you think would be really useful? P:Well useful? S: Yeah. P: Well, a bit of like, it could be useful if I had more like answers and you helped me with that. You helped me with answers I don't know. and with answers I do know sometimes. S: good man	Student SSI
Do you want me to give you a hint? P: Yeah. S: I'll take this off you for a second. (marker) Watch this. (draws 6 circles on the side of the whiteboard) and so far You've done this. (draws a line segmenting 0 and 6) So, so far you've done this. And you've got zero (pointing to one side of the line) plus six (pointing to the other side of the line) equals six. P: Yeah. Also, what you did, which was really good, was this here. (draws a line segmenting the 6 circles into 3 and 3) And you did three. (pointing to one side) Plus three (pointing to the other side). P: Plus three, S: exactly. Okay. P: So what's the hint? S: So that was the hint. So do you see what I did? P: No. S: I split them up with a line. Can you split them up with a line in a different way?	Flexible interview transcript

S: Oh, OK. I'll go with this. (puts 6 units back together) I'll go with this one. What if I've got two over here? (moves two to one side) P: I can't think of two more answers. S: Yeah, but I'm sure you can. So OK, so we have two over here. And four over here. So now we have one, two, plus one, two, three, four. (counting the units in the different sets) That equals six. What do you think of that?	Flexible interview transcript
S: So watch me. Careful now, watch me. (draws a line segmenting the drawn squares into 4 and 1 sets) Ok so what I've done, If you look over here (to the drawn squares) P: it's 4 plus 1, S:yeah 4 plus 1	Flexible interview transcript
S: How many is at the party now, Peter? P: Five. S: Are you ready for your mind to be blown? P: Yeah. S: So you have five. And then two leave. And you're ending up with three. (showing 5-2=3 in copy) And the same way. You start with the three. And then the two come back. (showing 3+2=5) And you're ending back with the? P: Five. S: So do you see how they work the other way around? P: Yeah. S: Five minus two equals three.	Flexible interview transcript

Making sense Is the mediator promoting meaningfulness in the task?

Excerpt	**Source**
S: And how many is left of the party? P: Three. S: (writes 5-2+3 in copy) Now, this time. So we have five minus two equals three. Now, if we have three at the party. And we add two to back to the party. (moves 2 units back to the first side)	Flexible interview transcript

They come back to the party. How many is here? P: So they went to go use the restroom. He's like, guys, I'm going to go use the restroom	
P: Basically, pluses and minuses are brothers.. . but They don't get along very well. S: They're kind of opposite brothers, are they? That's a really cool way of thinking about it	Flexible interview transcript
I try to learn things from young people and I try to tell other people then how to do it. And I think the way you described that was really cool. They're like brothers, but they're like opposite brothers. I like that. Good job. P: They're both opposite of each other. The plus adds on numbers. And then the minus takes away the number.	Flexible interview transcript
S: They're kind of like brothers. They're opposite brothers. And the reason you said that, which was really clever, I liked it, was you did something like this. P: Like this is a plus. Adding on S: Yeah. P: So once you have three and two, they're like separated from each other. (with 3 units on one side of the partitioned whiteboard and 2 on the other side) The plus helps it break through and make a number together.	Flexible interview transcript
Minus keeps them locked up. That's really clever. I love that way of describing it. So you have five because the addition brings them together. (referring to the units on both sides of the partition) So that's five. And the subtraction keeps them locked up. Keeps them away, doesn't it? (separating the 3 and the 2 units) P: Yeah, keeps them away from each other. Like there's like a wall. Like an invisible wall that they can't get connected through. To make an answer. But they can still count each other. S: Yes, I like that. Cool explanation.	Flexible interview transcript

S: you can see these numbers. So five, so we have five altogether. And when two leave the party, we have three left. (referring to both the sum written down in copy and the units on the partitioned whiteboard) But then if you add two back to three, you get five. (again referring to both the units on the board and the written sum) So five minus two equals three. And three plus two equals five. P: So guys, I'm back from the bathrooms! The bathrooms.	Flexible interview transcript

Monitoring Is the mediator ensuring that the child is checking his/her answers?

Excerpt	**Source**
P: Like, Ms. Heaney is like.. Are you sure that's the answer she says.. when I get an answer wrong. So that how I know like .. She's like, cooperative to me. And saying Like I got the wrong answer. Not like the main one. S:Okay. That's very nice of her, isn't it? P:Yeah, she's, she's cool, she's a cool teacher. S: Well, that's really good to hear.	Student SSI
S: anything else that you found might be really helpful or anything that you learned or anything about the way that we learned things that was helpful? P: that we learned is you being like a bit sarcastic a bit. I think S: A bit sarcastic was I, Oh, can you remember when? P: In like different questions? You're a bit sarcastic S:Oh, I'm sorry, was that hurtful? P:No, it was okay. S: Can you explain to me when I was being sarcastic? Just so I know for other students P: Like miss Heaney.. She's like, a bit sarcastic too. S: Okay. P: Like when she says, Are you sure? And like in a sarcastic way. Like, S: Oh, okay. P: Like that way. S: Oh, okay. So I was trying to just make sure that you were checking your answers and that	Student SSI

you were doing the right thing? Is that what you
were talking about?
P: Yeah.

P: Its 16!
Flexible interview transcript
S:So 8 plus 4 equals what?
P: 16.
S Okay, can you write out the full sum for me
(in the copy)
P: That's how you do it.
S: Oh, thanks for telling me.
So 8 in the first box.
P: *writes 8+4=16*
S: 8 plus 4 equals..?
P: 16.
S: So can you say that for me?
P: 8 plus 4 equals 16.
S: Is that right?
8 plus 4 equals 16.
Does that look okay?
P: *nods

P: (starts counting each block) 1, 2, 3, 4,5,
Flexible interview transcript
6, 7,8,9,10,11,12, 13, 14,16
16
S: 16 is it definitely?
P: Yeah.

The exact same answer as one more (referring to
Flexible interview transcript
one more than previous sum)
Okay. That's 18.
S: Ok How would we know if they were
definitely right?
P: Double check.
S: how would we double check that.
P: Number line.
S: Okay. Do you want to check the number line?
P:Yeah.

The exact same answer. (as the previous sum)
Flexible interview transcript
S: Yeah.
Okay. Do you want to check this one for me as
well? (the previous sum 9+7)
P: Yeah.
S: So can you check this one for me? (referring
Flexible interview transcript
to 8+7)
P: This one?
S: Yeah.
Check on the number line.

P: So you want me to check this one right here?
(8+7)
S: Yeah. Do you want to check that one for me? Or do we need to check the other one. Or is there anything we can do?.
Flexible interview transcript

S: (counting the remaining blocks)
Flexible interview transcript
we have 1,2,3,4,5
P: Yeah.
S:Is that right?
Is nine minus five five?
P: Yeah
I know. (writes 2+4)
Flexible interview transcript
S: two plus four equals..?
P: Fifteen?
S: Fifteen. You think?

Okay, start off with this one for me.
Flexible interview transcript
What does that first one say, Peter? (shows page 24 of figure it out 1 workbook: number line on top of page)
P: Seven minus eight.
S: Seven minus eight. Are you sure that's what it says?
P: Yeah.
Seventeen.
S: Yeah, write the answer.
Flexible interview transcript
P: 9 again
S: How sure are you that that's right?
P: I don't know.
S: Are you positive or are you thinking maybe it's right?
P: Maybe.

First one, 15. (Peter writes 15)
Flexible interview transcript
Good job. Minus.
Six.
Equals. (Peter writes sum in copy)
P: 11?
S: How do you know?
Did you check your number square?
Check your number square. See how you got it.
P: I got it wrong I need a rubber

P: Thanks.
Flexible interview transcript
its Nine.
S: Are you sure?

S: You know which one is seven? So why is that one nine?
Flexible interview transcript

So, do you want to check your number line and see if you're right? I'll give you the number line. (gives number square) P: Okay. Eight. Why is it eight again? Oh ya	
P: Three. S: You sure? Can you show me? P: Two. So it's two? *looks at me for reassurance* *long pause* I don't know if it is or it's not.	Flexible interview transcript
P: (puts black, 2 green, 2 red) S: ok Is that right? P: Yeah. S: So, we had (pointing to the pattern) black, green, two red. We had black, green, two red. now We've got black. (pointing to what Peter put down)	Flexible interview transcript
S: Oh, you're counting out three. So do you think there's three in the difference between one and three? P: Yeah. S: So lets count, one Two. (puts one finger up) Three. (puts 2 fingers up) So how many is between one and three? P: Two.	Flexible interview transcript

Planning Is the mediator encouraging planning: showing what to do before beginning to solve the task and how to set achievable goals?

Excerpt	**Source**
What are you going to do? P: I normally just go to the line number. S: You can use anything you like. Okay, what's your plan? P: *reaches over and grabs some unit blocks*	Flexible interview transcript
P: Here's a way to do it. (starts drawing circles) S: OK. So I want you to take a break for a second. (rubs out circles) P: OK. S: It's fine. I want you to take a break for a second because I want you to have a really good think about it before we start. So I want you to come up with as many new ways as possible to make up this one (pointing	Flexible interview transcript

to 6 circles). P: OK.	
S: But what's your plan? Because you need to get them all right. You should do as many as you can. So what's going to be your plan here? P: I'll do three plus three. S: Well, that's going to be one. And then what are you going to do after that? they have to be all different ones, don't they?	Flexible interview transcript
S: So do you understand the game? P: Yeah. S: Okay. S: So before you start, I want you to think for two seconds. its Really important.	Flexible interview transcript
P: I might draw a little circle. I might draw a circle that might have a little spine. S: Okay. But I want you to think about the game. How are you going to make as many sixes as you can? What's going to be your plan?	Flexible interview transcript
S: So Peter. You have this way of making six and this way of making six (referring to the 2 sets of circles drawn).But I know there's some more. How are you going to get them? Have a good think now before you start drawing. P: The way to get six? S: Mm-hmm. P: You never said anything about doing the same answer On the other side?	Flexible interview transcript
S: (counting them) Two, three, four, five six Now we need to get our thinking brain on here. We need to get a few more. P: Two. (more) S: How are we going to get six? How am I going to make up six?	Flexible interview transcript
Now. Over here. I want you to write our next sum which is twelve. Twelve. minus. Eight. P: (writes 12-8) S: So. What's that? What's the plan?	Flexible interview transcript
P: I'm not writing. I'm not making a number line. I'm doing dots. S: You're not making a number line. Oh, dots. Okay. So, tell me about your plan here. P: So, look.	Flexible interview transcript

I'm going to draw twelve dots.
Two. Okay. One, two, three, four, five, sic, seven, eight, nine, ten, eleven,
Twelve. Twelve dots. (draws 12 dots in whiteboard)
S: Now, what's your plan?
P: Then I want to rub out eight.
S: You want to rub out eight?
ok be very careful.

Scaffolding Is the mediator gradually building up skills, giving less and less help until the child takes over responsibility for learning?

Excerpt	Source
But for now, is there anything that you learned when we were doing our maths that you think would be really useful? P:Well useful? S: Yeah. P: Well, a bit of like, it could be useful if I had more like answers and you helped me with that. You helped me with answers I don't know. and with answers I do know sometimes. S: good man	Student SSI
S: Can you draw this out for me? Maybe little dots. (draw little dots) P: Okay. So can you do the first one for me? Four plus five equals nine. Can you do four dots plus five dots? P: (draws 4 dots and 5 dots) S: There you go. There's four dots plus five equals. P: Nine.	Flexible interview transcript
S: so if I did this and split them. (draws a line to segment the 9 dots into 5 and 4) P: 5 and 4.. 9 S: (writes 5+4=9) P: Yay! S: Now, if we have, there's nine all together, isn't there? (circling around all 9 dots) P: Yeah. S: Okay, so nine. Now, if we took away the five, (pointing to the segment with 5) how many would we be left with? P: The five? S: Yeah.	Flexible interview transcript

P: We take away one dot?
S: If we took away these five. (circling around the segment with 5)
P: Oh, so it's zero.
S: So, it's going to be four.

So did you see? Flexible interview transcript
So if you look at it over here,
you split them up like that. (referring back to the 6 circles on the whiteboard, and drawing a line to segment 2 and 4)
And we have two and?
P: Four.
S: And two and four is?
P: Six.
S: Cool.
Good job.
Can you think of one more way?
S: So, have a look over here for a minute. (Puts 6 units back together) Flexible interview transcript
So Peter
If I do this one (move one unit to the side), what am I going to make? Is that new?
P: five?
S:Five and?
P: One?
S: Yeah.
P: (draws one circle and five circles on whiteboard)
S: There you go.
P: (moves two units across the partition to leave 3 and 2) Flexible interview transcript
S: Okay. What's the sum?
Can you write it out for me?
P: (pauses and shakes his head)
S: It's tricky, isn't it?
P: Yeah.
S: That's okay. Don't worry.
So how many do we have altogether?
P: Five?
S: Yeah. These ones (points to one side) and these ones (points to other side) equals five.
Okay.
So if we.
Have five. We started off with five. And we took away this many (points to two we moved to other segment).
How many would we be left with?
S: Okay. So what's the sum? Flexible interview transcript
P: three Minus.

Two.
S: We start with the five.
I think you're getting it. Five. And we take away.
P: Two.
S: And we end up with.
P: three.
S: Yeah.

What's that?

Flexible interview transcript

Five minus zero equals? (pointing to the copy where it is written)
P: Five minus zero.. five
S: Watch my next one, okay?
So five. We start with five.
And I'm getting rid of one. (moving one over to the other side of the partition)
So he's going over there.
P: Bye-bye.
S: So now we have five.
P: So these guys are having a party. He left the party. (referring to the units on the first side and grabbing the one unit on the other side)
S: Yeah So put it over here. (the unit on the other side of the partition)
P: He's like, see you guys later.
S: (writing the sum in the copy) Minus what? Five minus?
P: One.
S: Because he left the party, didn't he?
P: Yeah.
S: And how many's left of the party?
P: four
S: Hey!
Good man.
Job done.
P: (picks up another unit from the first segment and moves it with the other unit)

Flexible interview transcript

The other guy went with him. Over here.
S: Now, so what's happening?
Can you write that out for me?
Start with five.
P: Five.
S: Minus? How many left the party?
P: Two.
S: Equals? How many's left?
P: Equals... Four??
S: How many's left?
S: So what's our next one?

Flexible interview transcript

P: Break them up. (takes another unit and

brings it to the other side)
Three left.
S: So we started with?
P: High five.
S: High five, yeah. So you can write it down for me. Five.
P: Minus two.
S: How many left?
P: Three.
S: Equals? How many are left at the party
P: two (writes sum down in copy)
S: Now, So you've got the opposite brother, haven't you?

Flexible interview transcript

Because, I'll explain it to you again, watch. So we start with six. (pointing to 6 in the sum copy and 6 units on one side of the board)
Minus one. (points to copy and moves one unit to other side of the board)
P: Minus comes along.
S: Exactly, and how many are left at the party?
P: Five.
S: And then we find the opposite brother, which is the addition.
And then we've got five plus one when he comes back to the party. (shows sum in copy and shows the unit moving back to the other side of the partition)
P: When he takes down the wall.
S: Yeah, equals.
P: That makes . six again.
Watch me do it with two this time, okay?

Flexible interview transcript

So I'm going to find the opposite again. So first of all, we're starting with six. (6 units on one side of the partition, writes 6 in copy)
Watch me.
So six.. I'm going to take two.
Two are leaving the party. (Moves two units across partition)
P: Now minus comes!.
S: Exactly, okay. (writes 6-2 in copy)
Minus two equals what?
How many is left at the party?
P: Equals four.
S: Four are left at the party. (writes 6-2=4)
Now can we find the opposite and get the addition?
So we have to start with four that are left at the party.
Now what's the next bit?
P: we add.. plus comes along..

And he brings two, so two.
S: Yeah, he brings them back. Exactly.
How much does that equal?
P: Six. Yay!
S: Hey, good man.

Self-regulation Is the mediator trying to ensure the child slows down, reflects and takes his/her time?

Excerpt	**Source**
P: Is this thing magnetic? (putting eraser on whiteboard) S: It is magnetic, yeah, that's right. P: Magnetic. S: I'm going to show you something a little bit different, okay? P: It's so light, I don't think it's magnetic. S: Can you do this one for me, please? (writes 4+5)	Flexible interview transcript
It's pretty cool, isn't it? P: Yeah. S: Yeah. P: *starts singing and nodding his head* S: Have a look at this one (writes 9-5)	Flexible interview transcript
Now can you draw this one out for me? Nine minus five equals four. P: Okay. S: take your time now. Let's get our nine.	Flexible interview transcript
P: I want this colour. Researcher, what colour was in here? (pointing to empty space in box of markers) S: I'm not sure, you know. Well, it could have been a black or a blue marker. So, how many dots do you have there, Peter? Can you count for me?	Flexible interview transcript
Is this a really tricky game for you Peter? P: (putting his hand on his forehead and sighing deeply) It's too tricky. S: Is it? P: Yeah. S: Do you want me to give you loads of help? We can do it together. P: I don't really like this game. S: Oh, you don't like it? P: No. S: Oh, okay. That's fine. P: It's too hard.	Flexible interview transcript

S: It's tricky, isn't it? P: Yeah. S: Yeah. That's okay. Don't worry about it. Will we do it nice and slow together. P: that's fine S: Good man. You're doing great... Do you know what? You're a great man for sticking with it. Okay? So we're nearly finished.	
P: (starts doodling on whiteboard) S: what's that? Is that you? Okay. You ready? I'm going to challenge you now	Flexible interview transcript
Your turn is next. So, when we start with five. And one leaves the party. You're left with? P: what? S: Start with five. One leaves the party. P: (flicks the unit away with his pencil) S: Careful now. P: He left S: Yeah, but he has to stay here, okay? (putting the unit back on the whiteboard) then you're left with? P: He's gone home. S: How many? P: Four.	Flexible interview transcript

Sharing Is the mediator interacting in a way that communicates that he/she is on the child's side, that they are working together as a team?

Excerpt	Source
S: Okay. And I want you to talk me through how you're doing each sum. P: How I'm doing my sum? Counting! S: Yeah, I want to learn from you.	Flexible interview transcript
S: How about this? We'll play a game, Peter. P: What game?	Flexible interview transcript
S: I want you to draw for me, Peter, as many ways as possible to make up six.	Flexible interview transcript

P: Six? S: Mm-hmm. So we're going to do it as many ways as we can. OK?	
S: And I want to learn a little bit more about you today, and about how you do maths. And you were so clever last week.	Flexible interview transcript
S: I just want to learn a little bit about how you were doing your sums. Because you're telling me, but I also want to see how you're doing them every day	Flexible interview transcript
S: Now, let's see. My turn next, okay? (moves another unit over the partition to leave 3+2) Oh. What does that say?	Flexible interview transcript
S: Now I want us to try to figure out all the different ways that we can do subtraction with this five (units) (whiteboard still segmented in half). Okay?	Flexible interview transcript
S: I try to learn things from young people and I try to tell other people then how to do it. And I think the way you described that was really cool. They're like brothers, but they're like opposite brothers. I like that. Good job.	Flexible interview transcript

Verbalising Is the mediator encouraging the child to talk aloud when doing the tasks in order to highlight their thinking?

Excerpt	Source
P: Our favourite. My favourite thing about the S: about the maths P: Oh, you mean? The maths S: Yeah, about the maths we were doing. P: Ummm.. we were doing like hard questions and minus questions too.. the plus... And I explained this. at First I realized, what was I doing? I might as well just teach this because I just knew S: That's so clever. Did you feel like you had to explain it and nearly teach it? P: I would say kind of.. Yeah, I wanted to teach it to you but you have to keep it a secret.	Student SSI

S: Yeah. Because it was really clever the way you explained it, but I really, really liked it. Good, man. So is that one of the favourite things that you did? Because you were able to talk about it and nearly teach it? And that was a good way of learning?
P: Yeah,
S: okay. Good.
P: teach it to you because You really needed it. And you'd be able to do it.

Student SSI

S: okay. Yeah, that's fine. Do you find that helps you to learn when you're able to explain it?
P: Yeah.
S: Yeah, I find that really interesting. Because you have a really interesting way of explaining things Peter
P: for some sort of .. I have a bit of an interesting brain

Student SSI

P: Tens.
S: Okay. And I want you to talk me through how you're doing each sum.
P: How I'm doing my sum?

Flexible interview transcript

S: Will you do that for me?
and I'll steal your number line so you can't have it.
What are you going to do?
P: I normally just go to the line number.
S: You can use anything you like.
Okay, what's your plan?
P: *reaches over and grabs some unit blocks* I'm gonna make a number line.
S: Okay, you're gonna make a number line. Interesting.
Tell me your plan as you're doing it. I like it.

Flexible interview transcript

S: Good job. So how are you going to do the sum now?
P: I'm counting them all.
S: Okay, let me see you.

Flexible interview transcript

P: Well, we don't have blocks now.
S: But if you had, could you show me how to do it? Could you explain it to me?
P: We can do my little brother and me.
S: Yeah, I'll pretend.
So, Peter how do I do four plus five?

Flexible interview transcript

S: OK, so what do you have to do here? P: All right. You're asking me to write three again. (first one shows 3 beach balls segmented into 2 and 1 by a line.., sum underneath reads 2+1=_?)	Flexible interview transcript
S: I'm going to see, okay? Can you make sure you're talking to me while you're doing it. And explaining it to me. P: So look. S: Mm-hmm. P: Look at this. Three. (draws three circles on one side of the plus)	Flexible interview transcript
. Two. Okay. One, two, three, four, five, sic, seven, eight, nine, ten, eleven, Twelve. Twelve dots. (draws 12 dots in whiteboard) S: Now, what's your plan? P: Then I want to rub out eight. S: You want to rub out eight? ok be very careful.	Flexible interview transcript
S: Now, what do you think we should do next? How are we going to figure out another sum that makes five?	Flexible interview transcript
S: What do you think we have to do here? (Pointing to the whiteboard with the sequence written) P: Here? S: What do you think we have to do? P: Here? S: Yeah.	Flexible interview transcript

Appendix 29

Full Outline of Pattern Matching and Thematic Analysis for Each of the Five Theoretical Propositions for Pilot Data.

Proposition 1: MDA will Enhance Domain General Learning Functions Following the Implementation of Mediated Learning Experiences Consistent with the Theory of SCM..

Does Not Do	**Relevant Mediated Learning Experience Examples**	**Structural Cognitive Modifiability**
P: 9 plus 3? (reading the next sum) S: We'll do one more. 9 plus 3. P: Is 12. I didn't even have to count for him. S: You didn't have to count? P:It's so clear. S: How did you do that to? P: Because brain. (pointing to his head with his pencil) **(Flexible interview 1: line 96)**	Now. Over here. I want you to write our next sum which is twelve. Twelve. minus. Eight. P: (writes 12-8) S: So. What's that? What's the plan? (Planning) **(Flexible interview 1: Line 1414)**	S: So now we have five. P: So these guys are having a party. He left the party. (referring to the units on the first side and grabbing the one unit on the other side) S: Yeah So put it over here. (the unit on the other side of the partition) P: He's like, see you guys later. S: (writing the sum in the copy) Minus what? Five minus? P: One. S: Because he left the party, didn't he? P: Yeah. S: And how many's left of the party? P: four **(Flexible interview 2: line 1708)**
Next one shows 5 cars split into 3 and 2, no numbers only 3 spaces provided underneath) P: *writes 3* Then write a two. *writes 2* Then I'm going to get my answer for you.	And we have five, okay? So, here's a sum we have on this side. We have how many? (placing all 5 units on one side of the	. S: Now, if we have three at the party. And we add two to back to the party. (moves 2 units back to the first side) They come back to the party.

Hold on. That’s 5.
S: How did you get that? You didn't even count them.
P: the answer,, It just appeared out of nowhere in my head.
S: It just appeared out of nowhere in your head, you just knew that one?.
P: Yeah.

(Flexible interview 1: line 676)

partitioned whiteboard)
P: Five.
S: On this side we have how many?
P: Zero.
S: So, five plus zero equals?
P: Five.
S: Okay.
P: (writes 5+0=5 in copy)

(Scaffolding)
(Flexible interview 2 line 1478)

How many is here?
P: So they went to go use the restroom.
He's like, guys, I'm going to go use the restroom.
S: Yeah.
P: I'm going to go use the restroom.
S: How many is at the party now, Peter?
P: Five.

(Flexible interview 2: line 1835)

S: Okay.
But I want you to think about the game.
How are you going to make as many sixes as you can? What's going to be your plan?
P: Well, I think you're going to see.
S: I’m going to see, okay?

(Flexible interview 1: line 877)

S: Now, what do you think we should do next?
How are we going to figure out another sum that makes five?

(**Planning)**
(Flexible interview 2: line 1489)

S: Oh, seventeen minus eight. Okay.
Okay, so I want you to write it out here for me. (in the copy)
And how would you do that? Because you explained...
P: Nine.
S: What?
P: Nine.
S: How did you get that?
P: Nine. I knew it all the time. (points to his head with pencil)

(Flexible interview 1: line 1253)

S: Now, let's see. My turn next, okay? (moves another unit over the partition to leave 3+2)
Oh.
What does that say?
P: Three plus two.
S: Okay.
Three.
P: Three.

Three.
Plus.
Two.
S: Equals.
P: (writes 3+2=5)

(**Sharing and scaffolding)**
(flexible interview 2: line 1501)

P: So once you have three and two, they're like separated from each other. (with 3 units on one side of the partitioned whiteboard and 2 on the other side)
The plus helps it break through and make a number together.

(Flexible interview 2: line 1893)

S: Can you do this next one for me? (14-5)
How are you getting these Peter?
P: no its not 11.
9 again.

S: You're doing a lot of thinking there. What are you thinking while you're doing that?
P: I whisper stuff to myself and then I just...
S: What's it that you're whispering? Are you keeping it to yourself, keeping it a secret?
P: *nods

(Flexible interview 1: line 1276)

S: First one, 15. (Peter writes 15)
Good job. Minus.
Six.
Equals. (Peter writes sum in copy)

P: 11?
S: How do you know?
P: Book. (points to textbook in my hand)
I don't see it, but.
S: you've no number line.
So how have you got this?

S: Can you tell me this? What was your favourite thing about what we did together?

P: Our favourite. My favourite thing about the
S: about the maths
P: Oh, you mean? The maths..

S: Yeah, about the maths we were doing.

P: Ummm.. we were doing like hard questions and minus questions too.. the plus... And I explained this. at First I realized, what was I doing? I might as well just teach this because I just knew

S: That's so clever. Did you feel like you had to explain it and nearly teach it?

P: I would say kind of.. Yeah, I wanted to teach it to you but you have to keep it a secret.

(Student SSI)

(peter points to number square)

(Flexible interview 1: line 1325)

Proposition 2: MDA will Illustrate Reconceptualization of Maths Concepts that Follows Mediated Learning Experiences, Consistent with the Theory of SCM.

Pilot data: Evidence of patterns within the empirical data consistent with the pattern predicted by the theory of structural cognitive modifiability for domain general factors.

Evidence of Inability/Misunderstanding	**Mediated Learning Experiences**	**Structural Cognitive Modifiability**
It was noted he scored particularly low on number, algebra, word problems, and computation. The class teacher suggests this is consistent with her observations and suggests he has particular difficulties with number bonds. **(Teacher Consultation)**	S: Do you want me to give you loads of help? We can do it together. P: I don't really like this game. S: Oh, you don't like it? P: No. S: Oh, okay. That's fine. P: It's too hard. S: It's tricky, isn't it? P: Yeah. S: Yeah. That's okay. Don't worry about it. Will we do it nice and slow together. P: that's fine **(Self regulation)** **(Flexible interview 1: Line 1065)**	*Context: whiteboard segmented in two halves. 5 units on one side to explore number bonds* S: Now, what do you think we should do next? How are we going to figure out another sum that makes five? P: (moves one unit to the other side, leaving four and one) S: Oh, I like that. What does that say? P: Four. . S: Four plus what? P: One. S: Uh-huh. What's that? P: Five. **(Flexible interview 2: line 1489)**
	S: So watch me. Careful now, watch me. (draws a line segmenting	S: Okay. What are we going to do next? Your turn. P: Never said anything about switching them.

	the drawn squares into 4 and 1 sets) Ok so what I've done, If you look over here (to the drawn squares) P: it's 4 plus 1, S:yeah 4 plus 1, exactly so I'm just going to put it over here, (Moving one unit away) and it's going to be.. (drawing the circles either side of the plus sign on the whiteboard) **(explicit help)** **(Flexible interview 1: line 1102)**	S: Oh, okay. Show me your plan. P: Never said anything about that. P: Show me your plan then. (moves all three units across the partition and all two back the other way, instead of moving one unit across) S: Okay. Right. Okay. P: Never said anything about that. Nothing wrong with it. S: Okay. Write it out for me. P: (writes 2+3=5) **(Flexible interview 2: line 1515)**
Peter had difficulty completing subtraction computations even with the aid of a number line on the page as he only got 7/10 correct. From figure 4 it can be seen that Peter had great difficulty accurately completing three single digit addition computations without the aid of the number line. From this it can be seen that Peter may be continuing to develop his concept and understanding of numeracy. He appears to be reliant on a counting strategy using a number line to complete computations **(Error Pattern Analysis)**	So, tell me about your plan here. P: So, look. I'm going to draw twelve dots. Two. Okay. One, two, three, four, five, sic, seven, eight, nine, ten, eleven, Twelve. Twelve dots. (draws 12 dots in whiteboard) S: Now, what's your plan? P: Then I want to rub out eight. S: You want to rub out eight? ok be very careful. **(Making sense, verbalising)** **(flexible interview 2: line 1427)**	S: So what's our next one? P: Break them up. (takes another unit and brings it to the other side) Three left. S: So we started with? P: High five. S: High five, yeah. So you can write it down for me. Five. P: Minus two. S: How many left? P: Three. S: Equals? How many are left at the party P: two (writes sum down in copy) **(Flexible interview 2: line 1770)**
S: do you remember we did some work? And we played the six game and we drew six dots, and then we had to split them up? How did you find that? Was that difficult?	Watch this. I'm going to split this in half. Like this? Like this. (draws line down the middle of the whiteboard) P: What are you doing?	S: Okay, what about our next one? P: Next one... The guy says, hey, I'm leaving the party now. I've had enough. I'm tired. I'm going to bed, I'm leaving.

P
It was a bit difficult because I had to find like different answers with the minus and it was a bit hard.

S: You found that hard?

P: I found it hard I would say

S: Can you tell me do you prefer to use the number line for most of your sums

P:
Most of them? Yeah.

(Student SSI)

S: Okay. So. Now, look.
Give me that. (tens)
Good man. Watch this.
How many do we have? (holding 5 units)
P: (counts 5) Five.
S: Five. So, we have five all together.
I'm going to try to figure out how many sums I can make with my five. Okay?

(engaging, making sense)
(flexible interview 2: Line 1459)

Then he joins these. (moves another unit across)
S: How many did we start with, Peter?
P: five

S: How many left the party now?
P: Four.
S: How many is left of the party?
P: One. (writes sum out in copy) Look at that perfect one.

(Flexible interview 2: line 1783)

S: Okay. And I want you to talk me through how you're doing each sum.
P: How I'm doing my sum? Counting!
S: Yeah, I want to learn from you.
P: Counting. You just count
S: Okay, so is that how you do them? You count them?
P: Yeah.
S: Okay, can you show me?
P: I try to count them in my head but I normally use number lines

(Flexible interview session 1: line 40)

We have how many? (placing all 5 units on one side of the partitioned whiteboard)
P: Five.
S: On this side we have how many?
P: Zero.
S: So, five plus zero equals?
P: Five.
S: Okay.
P: (writes 5+0=5 in copy)

(Scaffolding)
(Flexible interview 2: line 1480)

Watch me.
So six.
I'm going to take two.
Two are leaving the party.
(Moves two units across partition)
P: Now minus comes!.
S: Exactly, okay. (writes 6-2 in copy)
Minus two equals what?
How many is left at the party?

P: Equals four.
S: Four are left at the party. (writes 6-2=4)
Now can we find the opposite and get the addition?
So we have to start with four that are left at the party.
Now what's the next bit?
P: we add.. plus comes along..
And he brings two, so two.
S: Yeah, he brings them back. Exactly.
How much does that equal?

S:So 8 plus 4 equals what?
P: 16.
S Okay, can you write out the full sum for me (in the copy)
P: That's how you do it.
S: Oh, thanks for telling me.
So 8 in the first box.
P: *writes 8+4=16*
S: 8 plus 4 equals..?
P: 16.
S: So can you say that for me?
P: 8 plus 4 equals 16.
S: Is that right?
8 plus 4 equals 16.
Does that look okay?
P: *nods

(Flexible interview 1: line 65)

Context: 6 dots drawn on whiteboard – exploring dividing them with a line to understand number bonds for 6. 3 + 3 and 6+0 already completed

Can you split them up with a line in a different way?
P: Yeah.
S: Show me.
P: (draws a line down the middle segmenting the circles into 3 and 3)
S: So what would that be?

P: Six. Yay!
S: Hey, good man.

(Flexible interview 2: line 2030)

So we'll just have one party, okay? (puts 4 back on the first side and moves one unit across the partition on the whiteboard)

S: So four minus
P: one

S: equals what? How many is left at the party?
P: equals 3..
S: Can you find the opposite brother to bring them back together?
What's the opposite brother to bring them back together?
P: Uh-huh.
S: what is it?
P: three.. plus one
S: Equals what?
P: equals.. (puts one unit back with the other 3)
four
S: Yeah, well done. Great job.
(flexible interview 2: line 2077)

S: So now two are leaving the party. (moving 2 across the partition)
P: Oh. by minus.
S: By minus and then....

So, how many is left at the party?
P: Um, how many? Two.
S: Two. (writing 4-2=2 in copy)
Can you bring them back together for me, Peter?

P: (brings two units back

P: Three.
S: Three plus?
P:Two.
S: No.
What is that? (pointing to the other side)
P: Three plus three.
S: Yeah. So you have to do it in a different way.

(Flexible interview session 1: line 948)

So now, how are we going to split them up in a different way to make six?
Show me.
P: Yes so take these and put them Down over here. (took two units from the middle of the 6 and put them at the bottom , but did not clearly segment the 2 groups)
Plus down here.
S: OK.
Can you write this one for me?
P: Yeah.
S: What is it?
P: So it goes like that.
Two at the top.
Two at the bottom.
Then down here. (draws 6 circles on the other side of the plus on the whiteboard)
S: That's still zero plus six, isn't it?
P: Yeah.
S: So we need a new way.
Because ..
P: I’m out of ideas (a little bit upset)

(Flexible interview session 1: line 985)

S: So we split them that way.
What other ways can you split them up?
P: (gestures to split them into 3 across the partition) Four.
S: So what is it, two?
P: Two plus Two.
Two equals four.
S: Yeah.
(Flexible interview 2: line 2099)

and 3 again)That way?
S: Well, you did that one already, but that's still three plus three, isn't it?
Let me see.

(Flexible interview session 1: line 1034)

In the context of doing the same game to explore number bonds with 5 instead of 6

But I'm going to do a different one now.
I'm going to do the five game
It's the same game.
Is this a really tricky game for you Peter?

P: (putting his hand on his forehead and sighing deeply)

It's too tricky.
S: Is it?
P: Yeah.

(Flexible interview 1: line 1056)

Proposition 3: The MDA Procedure will Illustrate Domain General Constructs (Affective and Cognitive) that are Under-Developed, Well Developed and in the Zone of Proximal Development

Evidence of empirical patterns consistent with the zone of proximal development for the learning function attention and concentration

Does Not Do	Does with Help	Does Independently
but Peter does not maintain attention for extended periods and the quality of his work can suffer as a result. **(Teacher consultation)**	The SET suggests Peter really benefits from one to one work and that his difficulties in maths are more pronounced when he is in the mainstream classroom, but he works very well with her. **(Teacher consultation**)	Numerous examples of Peter attending to work for extended periods

S: Now, so I'm going to start today and we're going to do a few sums
P: Okay.
S: And so you did a few of these for me last week. And I just want you to..
P: *gets up and walks around the table to get a pencil*

(Flexible interview)

S: Good job, exactly. It's 22.

P: Is this thing magnetic? (putting eraser on whiteboard)
S: It is magnetic, yeah, that's right.
P: Magnetic.
S: I'm going to show you something a little bit different, okay?
P: It's so light, I don't think it's magnetic.

(Flexible interview 1)
S: So, I'm going to draw this for you.
So, if we have nine dots, okay?
(Draws 9 dots, 1,2,3,4,5,6,7,8,9)
P: I want this colour.
Researcher, what colour was in here? (pointing to empty

So you can use these over here (drawn squares), or you can use the blocks (units).
So... First one, is going to be...
P: I want the sponge.
I'd like to have more than...
A little more than the sponge.
I think this would be good for cleaning,
S: for cleaning?
P: it looks like a sponge,
S: So watch me.
Careful now, watch me.
(draws a line segmenting the drawn squares into 4 and 1 sets)
Ok so what I've done, If you look over here (to the drawn squares)
P: it's 4 plus 1,
S:yeah 4 plus 1,

(Flexible interview 1)
P: Dots. That's what you call dots.
S: Okay. I like that plan.

P: (starts doodling on whiteboard)
S: what's that?
Is that you?

Okay. You ready?
I'm going to challenge you now.

P: yeah

(Flexible interview 1)
So five minus zero.
P: (starts grabbing the box with units in)
S: (takes them away from him)
What's that?
Five minus zero equals? (pointing to the copy where

space in box of markers)
S: I'm not sure, you know.

(Flexible interview 1)
S: Okay.
So, if we have nine all together, Peter.

P: Zero isn't a number. Why is it called a number?
Why is a W called a W? Its actually a V, a double V.

S: You're getting into really good questions now.
P: Look. (starts to draw a W)
It'll be rounded like this.
Because it is really a W.

(Flexible interview 1)

S: OK.
Good job.
P: (writing 12) It's only a one and a two.
It's not… its that easy.
S: It's good work, though.
P: What are those? (pointing to something in the distance)
S: You're getting distracted are ya?

(Flexible interview 1)
S: You just guessed. OK, so can we check if that's right?
P: Wait, that's six.
That's supposed to be six.
S: Oh, OK.
P: I actually have a big

it is written)
P: Five minus zero.. five

(Flexible interview 2)
P: You wanna see how I draw my circles?
(starts drawing circles on the whiteboard)
That's what a circle looks like.

S: Now, I'm going to take this whiteboard away from you. It's distracting you, isn't it?
Oh, say bye-bye to the circles.

P: I love it.
S: I know.
That's okay. We can do it a little bit more at the end.
Now, do you see my new pattern? (2 green blocks, a red block, 2 green blocks, a red block)
Can you figure that out?
P: Of.. course I can figure it out.

(Flexible interview)

Christmas tree.
That's hanged up.
I have like a Christmas tree
that's fully decorated.
I have two.
One that my sister made.
And one that my mum
made.

(Flexible interview 1)
S: so we started with 5
P: *goes to grab 5 more
units*
S: No, no. Weve got five
already. You've got to use
these ones
P: Just incase..
They fling off the
whiteboard and *mimes the
units flying off the table*

S: Okay. So write this one
out for me. I'm going to take
a break then. Okay? So start
with five.
P: Wait. Break?

(Flexible interview 2)
But I want you to try to be
clever and figure out how
this works. So we only need
these five. (units) Why don't
you take them in your hand?
P: They look kind of like a
Minecraft pickaxe.
S: Is that what they are?
A Minecraft pickaxe. Is that
the way that Minecraft
works?
P: *takes other units and
puts them in a formation on
the whiteboard*
Minecraft!

(Flexible interview 2)

Evidence of empirical patterns consistent with the zone of proximal development for the learning function meaningful responses

Does Not Do	Does with Help	Does Independently
S: Start with five. P: Five. S: Minus? How many left the party? P: Two. S: Equals? How many's left? P: Equals... Four?? S: How many's left? P: Three. S: You sure? Can you show me? P: Two. So it's two? *looks at me for reassurance* *long pause* I don't know if it is or it's not. **(Flexible interview)**	S: two plus four equals..? P: Fifteen? S: Fifteen. You think? P: Yeah. Or sixteen. I'm going to go with sixteen. S: Sixteen. How did you get that? P: Because. Two. Two pieces. I thought it was fifteen or sixteen. So I just guessed. S: You just guessed. OK, so can we check if that's right? P: Wait, that's six. That's supposed to be six **(Flexible interview)** P: Five. S: Minus. P: Minus. S: Five minus what? P: Zero. S: Five minus two. P: Hold on. Why don't I add more? S: No. We only worked with five. . Five. Just write it out for me. And then we'll finish up after. Minus three. P: What? S: Five minus three. P: Three? S: Equals. P: Equal? S: What does it equal? Five minus three. So five minus three equals? P: Two. **(Flexible interview 1)** anything else that you found might be really helpful or	S: So we started with five. How many left the party? P: Two. S: Who's left at the party? P: Three. S: You sure? P: Yes! S: Okay, write it down for me. P: (writes the answer in sum copy) Three. **(Flexible interview)**

anything that you learned or anything about the way that we learned things that was helpful?

P: that we learned is you being like a bit sarcastic a bit. I think

S: A bit sarcastic was I, Oh, can you remember when?

P:
In like different questions? You're a bit sarcastic

S:
Oh, I'm sorry, was that hurtful?

P:
No, it was okay.

S:
Can you explain to me when I was being sarcastic? Just so I know for other students

P:
Like miss Heaney.. She's like, a bit sarcastic too.
S: Okay.
P: Like when she says, Are you sure? And like in a sarcastic way. Like,
S: Oh, okay.
P: Like that way.

S: Oh, okay. So I was trying to just make sure that you were checking your answers and that you were doing the right thing? Is that what you were talking about?
P: Yeah.

(Student SSI)
First one, 15. (Peter writes 15)
Good job. Minus.

Six.
Equals. (Peter writes sum in copy)

P: 11?
S: How do you know?
P: Book. (points to textbook in my hand)
I don't see it, but.
S: you've no number line.
So how have you got this?
(peter points to number square)

Did you check your number square?
Check your number square.
See how you got it.

(**Flexible interview)**
S: Ready for my next one?
P: Yeah.
S: Just write it out here for me. (in the sums copy)
This time, we have 16.
Minus.
Eight. (writes in copy)

P: Nine.
Nine.
S: Now you're rushing through a bit.
How did you get that one?
Did you just think all the answers are nine?
P: No.
I know one is seven.
S: You know which one is seven? So why is that one nine?
So, do you want to check your number line and see if you're right?
I'll give you the number line.
(gives number square)
P: Okay. Eight. Why is it eight again? Oh ya

(Flexible interview)

Proposition 4: The MDA Procedure will Illustrate Domain Specific (Maths) Constructs that are Under-Developed, Well Developed and in the Zone of Proximal Development

Evidence of empirical patterns consistent with the zone of proximal development for domain specific learning functions.

Does Not Do	Does with Help	Does Independently
P: *writes 8+4=16* S: 8 plus 4 equals..? P: 16. S: So can you say that for me? P: 8 plus 4 equals 16. S: Is that right? 8 plus 4 equals 16. Does that look okay? P: *nods **(Flexible interview)**	S: So can you check this one for me? (referring to 8+7) P: This one? S: Yeah. Check on the number line. P: So you want me to check this one right here? (8+7) S: Yeah. Do you want to check that one for me? Or do we need to check the other one. Or is there anything we can do?. If you look at this one. 9 plus 7 equals 16. And 8 plus 7 probably equals..? P: 15. **(Flexible interview)**	P: six plus two? S: Mm-hmm. P: that's Eight. S: Eight. P: (writing 8) Big snowman. S: Good job. P: And another one. (writing 8 for the next sum 2+6, again an inversion of previous sum) S: Oh, that's the same as well? P: Yes. **(Flexible interview)**
S: do you remember we did some work? And we played the six game and we drew six dots, and then we had to split them up? How did you find that? Was that difficult? P It was a bit difficult because I had to find like different answers with the minus and it was a bit hard. S: You found that hard?	S: So did you see? So if you look at it over here, you split them up like that. (referring back to the 6 circles on the whiteboard, and drawing a line to segment 2 and 4) And we have two and? P: Four. S: And two and four is? P: Six. S: Cool. Good job. **(Flexible interview)**	P: and an answer switched around doesn't change anything. S: Yes, P: its still the exact same thing S: you're talking about with the.. when you're adding two numbers if you swapped them around, they're still the same? That was really clever.

P: I found it hard I would say S: Can you tell me do you prefer to use the number line for most of your sums P: Most of them? Yeah. **(Student SSI)**		P: they're literally the same numbers. What do you expect? **(Student SSI)**
S: Good job. Can you think of one more way? S: So we split them that way. What other ways can you split them up? P: (gestures to split them into 3 and 3 again)That way? S: Well, you did that one already, but that's still three plus three, isn't it? Let me see. **(Flexible interview)**	First one, 15. (Peter writes 15) Good job. Minus. Six. Equals. (Peter writes sum in copy) P: 11? S: How do you know? P: Book. (points to textbook in my hand) I don't see it, but. S: you've no number line. So how have you got this? (peter points to number square) Did you check your number square? Check your number square. See how you got it. P: I got it wrong I need a rubber **(Flexible interview)**	P: 9+7? I know that answer. 17 S: What? How did you know that? P: 17. S: What? How did you get that so quick? You didn't even count them up. P: Because this.. it's still... 1 more than this (points to previous sum) (standing up and drops pencil) S: Because it's one more than the one you already did. Is that right? P: *nods **(Flexible interview)**
		P: 11 plus 10, that's... Um... 21. S: 21? How did you get that? Oh, you forgot your equals. (Peter wrote the sum without the equals sign) P: Easy. Easy enough. S: did you think that was?

P: I said the answer was 21.
S: How did you get it?
P: Because 10 plus 10 is 20.
S: That's right, yeah.
P: And if I had one more...21

(Flexible interview)

Proposition 5: MDA will Provide Practical Information to the Teacher in Relation to the Student, Informed by Theories of ZoPD and SCM

Thematic analysis of teacher semi-structured interview

Expectations for external support
T: So if the group didn't work, then the next stage would be for the support teacher to take the child on their own with the consent of the parents. And assuming that the recommendations given to home hadn't been implemented or weren't helping as well in line with it, then we would definitely try and get an assessment done. S: And can you remember in your experience of teaching, whether there's been many cases where you've interacted with NEPS related to a child that's presented with maths difficulties in isolation, not with literacy difficulties or maybe emotional difficulties? T: No, I can't actually.. It would have probably been both. Yeah, and the literacy may have impacted greatly the difficulty in maths as you go up, the word problems increase. S: In relation to maybe your expectations for maybe a NEP psychologist that was to come into a school and to work with a child with Maths, kind of isolated Maths difficulties, what would your expectations be for that service? T: I'd expect them to be able to identify, I suppose, where that child was having difficulty inside the Maths curriculum, be very specific about it, suggest some possible reasons as to why that might be happening and give some recommendations as to how we could move forward to support them in the best way possible S: Have you ever had an experience of working with a student where, despite your efforts, that there's been no real improvement? That there's been kind of pervasive and lasting difficulties with maths? It's difficult because I know you've only kind of started back in SET, back in Ireland, so it might be different. SET: In SET, I don't think so. Not in... Well, there's a girl I work with at the moment in the other school I'm working in, and she has extreme numeracy difficulties. And I can't say I've seen much of an improvement since September. I suppose that's a short space of time to compare it. But...

S: Yeah, absolutely. Yes, it sounds great.
With regards to maybe support from external services, have you any experience with that? Or, you know, would you be inclined to look for support from, say, NEPS for someone who has maths difficulties?
SET: I've not had experience myself. But I know that student I'm talking about will be, we're trying to get an assessment at the moment for her.
So it's in progress. I suppose we're just waiting now for them to actually come to the school to carry out the assessments.
S: Can I ask you, what would your expectations be around NEPS's input with that?
What would you hope to get out of that?
SET: I suppose that they could give some advice and maybe recommend some programs that would be useful for her so that we'd have a clearer idea of how to help.
Yeah, really just advice.
You know, give us some ideas on activities or things we can do to help her.

S: Yeah, do you think that there's appropriate resources available for teachers in the area of numeracy?
T: I think teachers are flooded with all sorts of demands for a start.
Maths is one of the subjects of, there's many subjects in school.
And I suppose there's always scope for more support.
But it can be coloured in such a way that the teacher ends up doing more work and being more exhausted rather than it actually being a help.

T: I suppose after so many years of teaching, I'm very conscious of that.
Whereas when I started, I used to think, oh, good, this is called support, so it must actually be helpful.
And it might not turn out to be that at all. No, in my experience, more often than not, it's you in the classroom with the kids and you figure it out.

T: Yeah, I guess maybe just suggestions as to activities or games for that specific context of four classes.
Like they're in there now as we speak, being supervised, doing, playing bingo together, all four classes together. It's an activity that they can all do, that they're all benefiting from, an Irish Nullet bingo game.
So to have just, I suppose, suggestions as to maths activities or games that they could all do together, but that the levels are differentiated. Some more of those practical recommendations.

T: What you've done, I suppose, is very good.
You'll be finished up with him now. So it's then on to the back to the teachers to kind of figure out what to do.
He's moving forward now into a completely new world.
So that and preparing for that.

S: Can I ask you, what would your expectations be around NEPS's input with that?
What would you hope to get out of that?
SET: I suppose that they could give some advice and maybe recommend some programs that would be useful for her so that we'd have a clearer idea of how to help.

Yeah, really just advice.
You know, give us some ideas on activities or things we can do to help her..

Contact time

T: The difference for me was very obvious in that you came in and you were very personable with him and he obviously liked to spend time with you and do the work that you were trying to carry out.
My experience of a psychologist coming in is it's very formal.
It's a very short time, specific, and that doesn't work for small kids because one day they can be feeling great, they can have a great morning, the next day it can be completely different.
There's a lot of challenges that we don't even know about that's happened to them already before they come to school.
There's a lot of pressure on one visit from a psychologist where they carry out a whole lot of tests within an hour or so, whereas you coming over time and dipping in and out of it and spending time with the child was clearly more comfortable with that.

T: It's very helpful.
And like I say, there's not the huge pressure on just one visit or two visits. The fact that you were coming back a couple of times
and because school life is just, it's so intense, it's hard to quantify for other people unless you're actually in a classroom.
And like even different times of year, and you saw last week there with the Christmas concert and the focus of that, how everything is centred around that in that moment in time.
So, and there's different parts of the year. It's like slices of cake.
So it's, I really liked the fact that it wasn't just focused on one visit for the day.

Teachers observing the sessions

T: What would be maybe a bit interesting from a teacher's point of view because you're always stuck in a bubble and you don't often get to see the kids outside of your bubble.
So for me to actually sit in with the person doing the assessment, even for like three or four minutes or to watch it, you know, the way you videoed it, for me to even watch some of that footage would have been really interesting because I can hardly take straight in a class with four different levels.

Appendix 30

Thematic Analysis of Domain General and Domain Specific Learning Functions for Case 1 Data (Louise). Definitions are Derived from Checklists at "Learning resources": https://www.dynamicassessmentuk.com. See Appendix 21.

Thematic Analysis of Cognitive Learning Functions

Communication Is the child communicating their answers in a clear and coherent manner?

Evidence	**Source**
The class teacher suggests she may have comprehension or receptive language difficulty perhaps but interacts well with other students and staff.	Teacher consultation
S: So, just for this one, you might be able to explain it to me because you got so many of them right. But what was the did you do with this one? (8,16,24,32,_,_,_,) (L got this correct and wrote 40, 48, 56) L: Eights	Flexible interview
S: Oh, there's eight in the difference? Oh, sorry. Yeah, OK. Yeah, exactly. And this one then? (55,50,45,40,_,_,_) (L got this one correct wrote 35,30,25) L : Fives.	Flexible interview
Okay, next one. (1,3,7,13,_,_,_) (L got this right , wrote 21,31,43) *pause* What do you think? I wonder would the number line be able to help you? How would you be able to use that to figure this one out? *Pause* Are you trying to look for the differences between the numbers? L: Seven.	Flexible interview
Do you find it harder to explain how you do them than it is to actually do them? L: *nods* S: Really? Okay. Do you find that with a lot of things, or just with maths?	Flexible interview

L: Just maths
S: Just with maths. Really?
Okay.
S: Absolutely spot on. Can you describe that sequence for
me?
Pause

Flexible interview

Flexible interview

So when you think of that, Louise,
and you have to come up with some kind of an answer, an estimate, without actually doing it,
what would you do?
pause
What would your plan be?
pause
S: Yeah, exactly. Good job. Okay, so when you see this,
and you see that each bag holds 16 apples,
and we have 144 apples, how would you guess to see how, what's kind of the region of the answer,
or what kind of area the answer is in?
pause
Do you have any way to guess?
Pause

Flexible interview

As in we don't know how many times 16 goes into 144.
Is there any number that if it was there (pointing to 144 in the textbook), it would be easy?
pause

Flexible interview

Do you want to try the next one? (it takes 26 chocolates to fill a box. how many boxes can be filled with 390 chocolates?) Will you read it out for me?

Flexible interview

L: It takes 26 chocolates to fill a box.
How many boxes can you fill with 26 chocolates?
Pause
S: mm.. What's your plan here? you need to make a bit of a guess.
pause
So how many chocolates are in each box?
pause
It's 26, isn't it?

Let's try another one.
A bus can carry 46 passengers.
How many buses are needed to carry 828

Flexible interview

passengers?
So, what are you thinking?
Pause
Do you want to draw them out?
pause

Flexible interview

how many packets can we fill up with 952 biscuits?
So we have to try to make a guess.
So what do we do when we try to make a guess?
Pause

Flexible interview

so With 34 biscuits in each packet,
if we had 34 biscuits, then how many packets would we need?
Pause

S: and what's your plan when you see them? How do you approach it?

Flexible interview

What's the first thing you do?
L: umm see what the count is
S: OK, as in what's the difference between the numbers, is it?
L: yeah
S: And how do you do that? Do you just count up or do you know the numbers?
L: I usually know the numbers.

S: I'm only wondering because you did a really good job of that and you knew it kind of straight away and you didn't have to write it down or anything. And that's moving down in sevens, not even moving up.

Flexible interview

So, I was just wondering how you got it so quickly and so well. You did a great job with it. Did you just kind of recognise it? You just saw it?
L: emm.. I noticed the 70 and the 77 and then from 63 I started counting backwards.
S: Oh, OK.

Flexible interview

S: So when you see something like that, talk to me. What are you thinking in terms of your plan for how you're going to do that?
What's the first thing you're looking at?
L: umm.. half
S: so half? Can you explain it to me?
L: Half of four is two, half of 16 is eight.

S: Absolutely spot on. Can you describe that sequence for me? *Pause* How many is coloured in? L: one S: and how many is it split into? L: three. S: Divided into? One, two, three.. L: four.	Flexible interview
S: Spot on. Okay, so we could have three plus three. Okay. So I'm going to put it back again. I'm going to write it as A plus B. (writes A+B=6) And now, I'm going to write this. B is equal to eight. Is that okay? L: No S: why not? L: Because eight doesn't go into six. S: Oh Is it because eight is bigger than six? L: Yeah.	Flexible interview
S: Change it up, now. Actually, I'll just keep that there. So, if that's the case, can you tell me something about A and B? Can you give me a sentence to say what they can be and what they can't be? *pause*	Flexible interview
So you told me B couldn't be eight because it's too big, isn't it? So what can they be? L: ehh Five. S: Yeah. L: and 1 S: Between five and one, is it? L: *nods head* S: And could they be six? L: Six and zero. S: Yeah, exactly.	Flexible interview
S: Fifty-six, okay. So we're starting off with that big group of people, fifty-six. And then what does the teacher want to do? L: Make teams of seven. S: Okay. So what we want to end up with here is a team of seven. So we don't know how many, but we want to see how many there's going to be.	Flexible interview

Maybe you can draw some circles with seven in them. L: (Draws some circles with 7 in them)	
S: So can you give me a sentence to describe them and what can they be and what can't they be? … S: Is it easier to tell me? L:*nods head* S: Okay, why don't you tell me. L: They can't be more than six.	Flexible interview
S: Four minus two is two. Can you tell me anything about A there? Is there anything that A can be and anything that A can't be? L: A can be one or two.	Flexible interview
S: So what's the first thing you did? L: Drawed Four pairs of football boots. S: Okay, so four pairs of football boots. So four... L: (writes 4) S: whats the next bit? L: minus one	Flexible interview
S: So you can explain that to me. What did you do? L: Four times two is eight. Two plus two is four. Eight plus four is twelve.	Flexible interview
have we enough for four teams? L: Yeah. S: Yeah, you're absolutely spot on. How do you know we have enough for four teams? L: I counted from 36 up to 48.	Flexible interview

Nature of response Is the child answering with meaning rather than guessing randomly?

Evidence	Source
The abstract assessment began with some number sentences which were to be completed mentally. According to figure 1 it can be seen that Louise was inaccurate in completing some of these	Error pattern analysis
The next part of the abstract level assessment consisted of doing addition computations in columns. In general Louise performed well at these. She used the appropriate procedures but was inaccurate at times and may have forgotten to carry the 1	Error pattern analysis

What's the next one up then Louise? Flexible interview
L: Eleven.
S: Yeah, exactly. Great job. So then it's 11 plus 25 is going to be?
L: Thirty-three.

We.. *pause* double it. Flexible interview
So two multiplied by two is four.
Four multiplied by two is eight.
Eight multiplied by two is 16. (pointing to numbers in the sequence)
What's the next one?
L: Thirty-six.

S: Ok, Are you going to make this really hard, really easy, or medium? Flexible interview
L: medium
S: Okay, thanks.
It's Friday.
L: *pause*
(writes 1, 7,15, 23)
S: Wow, okay.
your turn. You can do one for me, you can do whatever you like. You've got your units there, you've got your pages here, you've got to figure out a sequence for me. Flexible interview

L: (writes 3,7,10)

Make it tricky for me now. Flexible interview
You did a really good job in the last one.
The last one was very tricky, actually.
L: *pauses*

writes 11, 20, 31

How many apples are in each bag? Flexible interview
L: 16.
S: Yeah, okay, 16 apples are in each bag.
And the question is, how many bags can you fill with 144 apples?
So.. if the question was different, and it said each bag has 16 apples, how many bags could you fill with just 16 apples? What would the answer be?
L: 16.
S: So it would just be, so 16 apples, and each bag has 16 apples.
So how many bags would you be able to fill

with 16 apples? L: two	
	Flexible interview
And here's our bus. (draws a bus on the whiteboard) And on the bus there are 46. (writes 46 on the bus) And we have 828. (writes 828 at the top) So, is it going to be more or less than 10 buses? L: less	
S: It's going to be less than 10, why do you say that? *Pause* So, if there was 10 buses, how many would we bring? L: 46. S: So, 46 is there, how many buses? L: one S: Yeah, so if there was 10 buses, how many? *pause* L: 10.	Flexible interview
L: Five..? S: So the first one is the difference between one and three, isn't it? (pointing to them on the hundred square) L: one S: Um... Between one and three, so... L: Two	Flexible interview
S: There were twelve apples in a bag, Ann sold five bags. How many apples did she sell? L: *writes 12 divided by 5=_*	Flexible interview
S: So Anne old five bags. How many apples did she sell? So is the answer going to be more than twelve or less than twelve? L: Less than twelve.	Flexible interview
S: Yeah, okay. Is it because in this sentence it said that she sold five? L: *nods* S: Is that what makes you think that it's going to be less? L: Yeah. S: So if we had said she has twelve apples in a bag, and she has five bags, that makes you think it would be more? L: *nods*	Flexible interview

Thematic Analysis of Domain Specific Learning Functions

Algebra

Evidence	**Source**
The class teacher suggests Louise has had difficulties with maths since beginning school. Louise is currently having difficulty with a number of strands of the maths curriculum including number and place value, shape space and data, algebra, time and word problems.	Teacher consultation
Figure 6 shows that she had some difficulty in completing equations. For more basic equations she was able to complete them accurately however for the majority he was unable to try. This will be explored in the flexible interview.	Error pattern analysis
The final part of the abstract level assessment was related to algebra. Figure 7 shows Louise had some difficulty in completing sequences. She completed simpler sequences with a fixed difference between elements. She also completed some sequences where differences between elements were varied. However she also was inaccurate with some of these and also did not see where elements of the sequence were being doubled. Perhaps she was reliant on a counting strategy to discern the difference between elements of the sequence as opposed to developing her sense of number to see the pattern in the sequence. This will be explored in the flexible interview.	Error pattern analysis
Fantastic. What about this next one? (1,4,9,16,_,_,_) (L got this one wrong and wrong and wrote 24,33,43) L: Threes.	Flexible interview
S: Yeah, and you got that spot on. So well done. What about our next one down here? (1,4,10,19,_,_,_) (L got this one wrong and wrote 30,42,53)	Flexible interview
S: OK, so tell me the difference between one and four is? L: Three. S: Yeah, and then you have four and nine. L: Five, S: yeah, exactly.	Flexible interview

And then you have nine and 16.
L: Seven.
S: Exactly. OK, so what's happening there?
L: It's.. going up every second number

two, four, eight, sixteen. What's the next one then? (2,4,8,16,_,_,_) (L got this wrong she wrote 28,46,62)

Flexible interview

Pause
That one a bit trickier?
L: *nods*
S: So when you see something like that, talk to me. What are you thinking in terms of your plan for how you're going to do that? What's the first thing you're looking at?
L: umm.. half
S: so half? Can you explain it to me?
L: Half of four is two, half of 16 is eight.
So, we've started here. (pencil on one on hundred square)

Flexible interview

Yeah, so we've jumped two. Okay, (moved pencil up to 3)
where are we going now?
To seven.
(puts pencil on 3 and starts moving up each square)
one, two, Three., Four. So the difference is ..?
L: four
S: Exactly.
Okay, what's my next number?.. 13 isnt it?
S: (counts each square from 7 to 13 on number square) four, five, six. So my next difference is six.
So whats going on there do you think?
pause
L: Umm going up in twos
Change it up, now. Actually, I'll just keep that there. So, if that's the case, can you tell me something about A and B? Can you give me a sentence to say what they can be and what they can't be?

Flexible interview

pause
So you told me B couldn't be eight because it's too big, isn't it?
So what can they be?
L: ehh Five.
S: Yeah.
L: and 1
S: Between five and one, is it?
L: *nods head*

S: And could they be six?
L: Six and zero.
S: Yeah, exactly.

S: Ok, Are you going to make this really hard, really easy, or medium?
Flexible interview
L: medium
S: Okay, thanks.
It's Friday.
L: *pause*
(writes 1, 7,15, 23)
S: Wow, okay.
Okay, so the difference between these is six, (writes 6 between 1 and 7)
the difference between these is eight, (writes 8 between 7 and 15)
the difference between these is also eight (writes 8 between 15 and 23)
I cant figure it out.. What's the pattern?
pause
.
Flexible interview
S: The last one was very tricky, actually.
L: *pauses*
writes 11, 20, 31
S: Okay, that is tricky.
Okay. So the difference here is 9 (writes 9 between first two), and 11 (writes 11 between second two)
Whats our next difference?
Pause
What is it going up in?
Pause
L: *nods*
Flexible interview
S: I'm going to write something on the whiteboard and I want you to have to think about it.
Tell me something about it. Okay, so I'm going to write this. (writes a+b=6)
Have you ever seen anything like that before?

L: ehh I've seen it before
Flexible interview
S: Okay, you have.
And do you find that kind of thing very difficult, or do you like doing work like this?
L: I've never done that.
S: Okay. So what do you think it means, or what do you think we have to do?
pause
L: A can be one or two.
Flexible interview
S: A can be one or two.

Will we try that out? OK So if A is one. And I have to take away B. Equals two. (1-b=2) L: three S: So one minus three equals two. Are you happy with that? L: *nods head*	
OK this one is going to be... (writes 11,23,35 on whiteboard) No there you go. *Pause* So what's the best way to figure it out? Do you like seeing it with the tens and units? Or do you like doing it this way? L: *draws arc between first two numbers and writes 12* *Pause* *writes another arc and 12 between next two numbers* S: good job so whats our next one going to be? L: *draws another arc and writes 12.. writes 47*	Flexible interview
S: You did really well. You showed me here (on whiteboard). Can you show me using these now this time? (pointing to tens and units) L: *Gets one ten and one unit, two tens three units, three tens and five units* S: great You might have to go digging now for the next one. (into the box to get more tens and units) L: *gets 4 tens and 7 units*	Flexible interview
A minus B. It's supposed to be a two. It doesn't really look like one. A minus B equals two. L: four minus two. S: Lovely. That's absolutely perfect. (writes 4-2=2)	Flexible interview
So what's the first thing you did? L: Drawed Four pairs of football boots. S: Okay, so four pairs of football boots. So four... L: (writes 4) S: whats the next bit? L: minus one S: The one is at the end but it's four pairs, isn't it? So we have two in each.	Flexible interview

How would we write that? L: Four times two. S: Yeah, brilliant, well done. L: Minus one. S: Minus one. Equals... L: (writes 4x2-1=7)	Flexible interview
that the football team scored two goals and two points but the other team scored one point more How many points did the other team score?. So you can draw it out for me if you like or you can write it down. So the football team scored two goals and two points L: *writes down 2x3+2* but the other team scored... What's the answer? L: 8	Flexible interview
L: *nods* S: Okay, we'll do just another one more. So a dog has four legs and a chicken has two legs. How many legs does two dogs and two chickens have? L: *writes 4x2+2+2=12*	Flexible interview
S: This time, the first team scored three goals and three points. The other team scored only goals but we don't know how many. The match ended up in a draw. How many goals did the other team score? L: (writes 3x3+3=12) *Pause* The other team scored four goals	Flexible interview

Word Problems

Evidence	Source
The class teacher suggests Louise has had difficulties with maths since beginning school. Louise is currently having difficulty with a number of strands of the maths curriculum including number and place value, shape space and data, algebra, time and word problems.	Teacher consultation
The abstract assessment began with some number sentences which were to be completed mentally. According to figure 1 it	Error pattern analysis

can be seen that Louise was inaccurate in completing some of these. For others she was unsure of the procedure (such as getting seven eighths of 56). On others there may have been too many computations for her to keep track of at once (e.g. what as to be added to 10 times 53 to make 600). For the flexible interview it will be interesting to see how Louise gathers information from number sentences.

So.. if the question was different, and it said each bag has 16 apples, how many bags could you fill with just 16 apples? What would the answer be? L: 16. S: So it would just be, so 16 apples, and each bag has 16 apples. So how many bags would you be able to fill with 16 apples? L: two	Flexible interview
As in we don't know how many times 16 goes into 144. Is there any number that if it was there (pointing to 144 in the textbook), it would be easy? *pause*	Flexible interview
It takes 26 chocolates to fill a box. It's told us that. So we have 390 chocolates. So how many boxes are we going to need so that they can all go into a box? L: twelve S: Okay, that's a really, really good guess.	Flexible interview
S: So, we were on this one, and we just said that, first of all, there's 26 chocolates to fill a box. How many would be filled from 390 chocolates? And you made a good guess, you said 12. And I wonder, can you tell me how you know that's close, or how you came to that guess? *Pause* Kind of like the last one. What number, if it was put there (pointing to 390 in the textbook), would make that sum really easy? L: Three.	Flexible interview

So, if we have 26 chocolates in every box, (rubs out 10 and writes 26) and we have 390 chocolates, (rubs out 60 and writes 390 at the top) how many boxes are we going to need? *pause* What number, if I put it up there, Louise, would make this really easy? L: Two.	Flexible interview
So, say for example with this bus one, okay, we have 46 passengers on the bus. That's how many can fit on one bus. And we have 828 passengers altogether. And here's our bus. (draws a bus on the whiteboard) And on the bus there are 46. (writes 46 on the bus) And we have 828. (writes 828 at the top) So, is it going to be more or less than 10? L: less	Flexible interview
S: It's going to be less than 10, why do you say that? *Pause* So, if there was 10 buses, how many would we bring? L: 46. S: So, 46 is on, how many buses? L: one S: Yeah, so if there was 10 buses, how many? *pause* L: 10.	Flexible interview
S: Do you think the answer is going to be more or less than 20? L: Less. S: Less than 20, why do you think that? L: I don't know.	Flexible interview
There were twelve apples in a bag, Ann sold five bags. How many apples did she sell? L: *writes 12 divided by 5=_*	Flexible interview
So there are twelve apples in a bag. (draws a bag) Twelve apples, right? (writes 12 in the bag) Okay. So Anne old five bags. How many apples did she sell? So is the answer going to be more than	Flexible interview

twelve or less than twelve? L: Less than twelve.	
S: So we're going to have one twelve, and two twelves, and three twelves, and four twelves, and five twelves. (pointing to each bag drawn) So what do you think our equation is going to be? L: minus? S: So it's actually multiplied by. Because she sold one bag of twelve,	Flexible interview
S: Okay, so enough for four teams. Brilliant. And the easy numbers here are usually multiplying by 10. So, if you had 12, say 13 in every team, (writes 13 in the box on whiteboard) the easy one to know is if we had 130 players, (writes 130 at the top) how many teams do we have? L: 10.	Flexible interview
So how many biscuits are in each packet? L: 34. S: Okay, and if we have 34 biscuits, then how many packets do we need? L: One. S: Yeah, just one. So if we had 340 biscuits, how many packets would we need? L: 10. S: 10, good on you, you're dead right. So is the answer going to be more or less than 10? L: More.	Flexible interview

Appendix 31

Thematic Analysis of Mediated Learning Experiences for Case 1 Data. Definitions derived from Checklists at "Learning resources": https://www.dynamicassessmentuk.com. See Appendix 22.

Challenging Is the mediator ensuring that tasks are challenging, without overwhelming the child?

Excerpt	Source
S: Do you find these ones tricky? L: a little bit S: And does it bother you trying to do them? Or do you like trying to figure it out L: its alright	Flexible interview
S: I'm going to write something on the whiteboard and I want you to have to think about it. Tell me something about it. Okay, so I'm going to write this. (writes a+b=6) Have you ever seen anything like that before? L: ehh I've seen it before S: Okay, you have. And do you find that kind of thing very difficult, or do you like doing work like this? L: I've never done that.	Flexible interview
S: How did you find today? Was it tough or was it too easy, or how did you find it? L: A bit hard, S: yeah. And does it bother you when things are a bit hard? Would you rather things be really easy? L: easy S: Would you rather it be really easy? (laughing) And do you enjoy when things are hard, but then you work through it and you get over it? That's a nice feeling, isn't it? L: *nods* S: So, sometimes it's nice to be challenged a bit. I know it was a bit mean because I was making things a bit difficult for you, but I just wanted to see if you could stick with it.	Flexible interview

Encouraging Is the mediator giving frequent, enthusiastic praise and encouragement in a way that provides valuable feedback to the child?

Excerpt	**Source**
S: How many goals? You can go without the goals, you can just do the points. L: *writes a goal* S: Are you doing it with a goal? Okay. How many points? L: *writes 1-04* S: Wow, great job. Well done. Perfect. L: That was tricky. S: Yeah, you did it though. You did it really well	Flexible interview
S: Fantastic. So what do you think the difference between the third one and the fourth one will be? L: Eleven. S: Good. So you can draw in your little arc and do eleven. L: (draws arc to show 11 between the next two numbers) S: so what does that bring us up to? L: *writes 45* S: Fantastic. Great job.	Flexible interview
S: Okay, why don't you tell me. L: They can't be more than six. S: Exactly. That is spot on.	Flexible interview
Is that tricky? Or is that easy? L: It was tricky at the start but I'm getting to know it. S: Yeah. You actually did really well at the start. And do you know what I think helped you as well? And you've gotten really.. a lot better at it since we started. Is that you started to talk about it and you kind of talked through the thought process. And I think that was really, really good.	Flexible interview
S: If there was 160 apples, would this sum be very easy? L: Yeah. S: Would it? Okay, what would the answer be? L: ehh.. 10. S: Yeah, exactly, spot on.	Flexible interview

Good job.

S: Ten, exactly, you're spot on. Flexible interview
So, if we had 260 chocolates, that sum would have been really easy, wouldn't it?
Because it'd just be 10 boxes.
But it's not, it's not 260, it's 390, okay? (rubs out 260 and writes 390)
So, is it going to be more or less than 10 boxes?
L: More.
S: More than 10 boxes, and you said 12, so that could be, that's a really good guess.
So, well done.
S: Yeah, so we'd have another 13 over here, wouldn't we? (writes another 13) Flexible interview
Fantastic.
So, we'd have enough for two teams. Would we have enough for three teams?
L: *shakes head*
S: No, okay. So, we have enough for two teams.
Great job, well done.

Flexible interview

have we enough for four teams?
L: Yeah.
S: Yeah, you're absolutely spot on.
. Flexible interview
How would we write that?
L: Four times two.
S: Yeah, brilliant, well done.
L: Minus one.
S: Minus one.
Equals...
L: (writes 4x2-1=7)
S: Brilliant, absolutely spot on.

S: 8.. So the team scored two goals and two points. Flexible interview
So there's your two goals and two points. (pointing to 2x3+2 written down)
So what did the first team score?
L: 8.
S: And the other team scored more than what did the other team score?
L: Nine.
S: Exactly, so this is going to be adding one at the end.
L: (writes +1 at the end of the equation)
S: Well done. Brilliant.
L: *writes 4x2+2+2=12* Flexible interview
S: So you can explain that to me. What did you

do? L: Four times two is eight. Two plus two is four. Eight plus four is twelve. S: Well done. Absolutely perfect.	
So we're in the same position. You're right, they got 12 points and you're right, they got four goals. So how do we get from 12 to four? What do we do? L: divide S: youre right divide Exactly, because there's three points in every goal, isn't there? Look how impressive that is. Look at that for a bit of work you just did. (pointing to the equation)	Flexible interview

Explaining Is the mediator asking for explanations, guiding the child to justify their answers?

Excerpt	Source
Was I asking you to do a lot of explaining about your maths? L: Yeah. S: Okay, tell me about that. Was that hard or do you think that was good? Tell me, what do you think about that? L: A little bit hard. S: Hmm. And do you prefer just to get on with your maths and not have to explain it? L: Sometimes. S: Yeah. And then sometimes, did you find it was useful? L: Yeah.	Student SSI
S: I might just ask you specifically about drawing on the whiteboard. So, we did that, if you remember, with the word sentences or the number sentences. Why was that so useful for you, do you think? Why did it help you so much? S: Do you think it's easier for you to draw the maths or do you think it's easier for you to talk about it? L: Draw.	Student SSI
S: So, just for this one, you might be able to explain it to me because you got so many of them right.	Flexible interview

But did you do with this one? (8,16,24,32,_,_,_,) (L got this correct and wrote 40, 48, 56) L: Eights	
What about this one? (4,10,16,22,_,_,) (L got this correct she wrote 28, 34,40) L: umm … Six. S: Yeah, going up in sixes, isn't it? Yeah, good job.	Flexible interview
What about this one? (84,77,70,63,_,_,_) (L got this correct, she wrote 56,49,42) L; Sevens. S: Yeah, going down in sevens, isn't it? Do you know your seven times tables? Are you really good with your seven times tables? L: Not really. S: Not really? I'm only wondering because you did a really good job of that and you knew it kind of straight away and you didn't have to write it down or anything. And that's moving down in sevens, not even moving up. So, I was just wondering how you got it so quickly and so well. You did a great job with it. Did you just kind of recognise it? You just saw it? L: emm.. I noticed the 70 and the 77 and then from 63 I started counting backwards. S: Oh, OK. Yeah. Yeah, good plan.	Flexible interview
L: Sums are easier, S: okay. Why are sums easier? What makes them so easy? *Pause* Is it because you know the rules and you have to, you know what you're supposed to do? And this is a bit more, that you have to kind of figure it out. L: *nods*	Flexible interview
You're doing a great job, though. You've got a lot of these right. I'm just interested in how you're figuring them out. You might talk to me about this one. (1,3,6,10,_,_,_) (L got this right she wrote 15,21,28) Three, six, ten, and fifteen. So what's going on there? L: Two.	Flexible interview

S: Do you mean you're going up in twos all the time?
L: Mm-hmm.

Flexible interview

So how many boxes are we going to need so that they can all go into a box?
L: twelve

S: Okay, that's a really, really good guess.
Give me your thoughts behind that. How did you figure out that guess?
S: So, we were on this one, and we just said that, first of all, there's 26 chocolates to fill a box. How many would be filled from 390 chocolates?
And you made a good guess, you said 12.
And I wonder, can you tell me how you know that's close, or how you came to that guess?

Flexible interview

Pause
S: Do you think the answer is going to be more or less than 20?

Flexible interview

L: Less.
S: Less than 20, why do you think that?
L: I don't know.
S: Yeah, okay.

Flexible interview

Is it because in this sentence it said that she sold five?
L: *nods*
S: Is that what makes you think that it's going to be less?
L: Yeah.
S: So if we had said she has twelve apples in a bag, and she has five bags, that makes you think it would be more?
L: *nods*
So can you Draw a picture. To Show me how you would think about figuring that out.

Flexible interview

L: *draws 4 pairs of football boots, puts a cross through one pair*
S: Tell me what you did.
L: I drawed four pairs of football boots and just crossed one out.
S: Okay, so what's the answer?
L:Three.

L: *writes 4x2+2+2=12*

Flexible interview

S: So you can explain that to me. What did you do?
L: Four times two is eight.
Two plus two is four.

Eight plus four is twelve. S: Well done. Absolutely perfect.	
So you did three goals and you knew that the other team scored three points less which meant that they scored six points. (pointing to the written equation) How do you know how many goals they scored? L: ehh I halved it. S: You Halved six. What did you get? L: Three.	Flexible interview
S: So did the other team score three goals? L: No. S: How did you get your answer at the end? L: I counted down two. S: You counted down two? L: In twos S: ok So how many points are in a goal? L: Three. S: So then how many goals are in six points? L: Two.	Flexible interview
Pause	
S: So if there's six points in a goal, or sorry three points in a goal and the other team got six points you were right in your answer how many goals did they get? L: Two. S: So how did you get from six to two? What was the thing that you did? L: Count. S: So if I want to see how many times three goes into six what do I do? L: multiply by 2	
S: Three, okay. So we're going from nine to three. How did we get there? How do you find out how many goals are in those points? L: count in threes.	Flexible interview

Explicit help Is the mediator having to give detailed feedback/assistance including explicit discussion of strategies in order to improve performance?

Excerpt	Source
Tell me now, what parts did you find fun and what parts did you not like? L: When I had to do it by myself I didn't really like it. And when you were helping me then I kind of liked it. S: Yeah, the first session was all on your own. I'd say that was very tough. L: *nods* S: Yeah, that's not nice.	Student SSI
L: Half of four is two, half of 16 is eight. S: Oh, cool, yeah. Yeah, absolutely. So then 16 is going to be half of whatever this number is, right? (pointing to the next space up in the sequence) L: mmhmm S: Cool, okay. What's another way of saying that? *Pause* So you're right. If two is half of four, how do we get from two to four? We.. *pause* double it.	Flexible interview
If there was 160 apples, would this sum be very easy? L: Yeah. S: Would it? Okay, what would the answer be? L: ehh.. 10. S: Yeah, exactly, spot on. Good job. So, I think when you're doing sums like this, sometimes the best thing to do is to see is it going to be more or less than 10? And then that will give you an idea of where you're at.	Flexible interview
S: So we're going to have one twelve, and two twelves, and three twelves, and four twelves, and five twelves. (pointing to each bag drawn) So what do you think our equation is going to be? L: minus? S: So it's actually multiplied by.	Flexible interview

Because she sold one bag of twelve,
and two bags, and three bags, and four bags, and
five bags. (pointing to each bag)
Okay.

Implicit help Is the mediator only having to give small hints, clues and prompts in order to improve performance?

Excerpt	**Source**
And now, I'm going to write this. B is equal to eight. Is that okay? L: No S: why not? L: Because eight doesn't go into six. S: Oh Is it because eight is bigger than six? L: Yeah. S: Yeah, okay. So if eight is bigger than six, and then we have eight over here (pointing to A), and I'm going to add something else over here to it (pointing to B) to get six. That can't be. L: *shakes head* S: What if I said this? What if I said B is equal to four? L: ehh yeah. S: Is that okay? Cool. And if B was equal to four, what would A be equal to? L: Two.	Flexible interview

So you told me B couldn't be eight because it's too big, isn't it? So what can they be? L: ehh Five. S: Yeah. L: and 1 S: Between five and one, is it? L: *nods head* S: And could they be six? L: Six and zero. S: Yeah, exactly. So, could it be zero? L: Yeah. S: Can they be one? L: yeah S: Two. L: yeah S: Three. L: yeah S: Four. L: Yeah S: Five. L: yeah S: Six. L: yeah S: Seven. L: No.	Flexible interview
S: Yeah, exactly. Good job. So, if it said each bag can take 16 apples, and we have 32 apples, how many bags would we fill? L: ehh 2. S: Yeah, exactly. Good job. Okay, so when you see this, and you see that each bag holds 16 apples, and we have 144 apples, how would you guess to see how, what's kind of the region of the answer, or what kind of area the answer is in? *pause* Do you have any way to guess?	Flexible interview
S: So, 144 is a bit of a sticky number, isn't it? As in we don't know how many times 16 goes into 144. Is there any number that if it was there (pointing to 144 in the textbook), it would be easy? *pause*	Flexible interview

S: So when you told me already that if there was only 16 apples, and there was 16 apples in each bag, then we know that the answer would just be one bag. And if it was.. if we had 32 apples, and there was 16 apples per bag, then it would just be two bags. Is there any other number that we could put there (pointing to 144 apples in the textbook) that would make this sum really easy? *pause*	Flexible interview
	Flexible interview
S: What amount of chocolates, if we had here, would make this one really easy? (pointing to the 390 in the textbook)	
S: Kind of like the last one. What number, if it was put there (pointing to 390 in the textbook), would make that sum really easy?	Flexible interview
S: So,.. if there was,.. again, we're talking about chocolates, okay? If we had a box of chocolates, and in every box of chocolates we had 10 chocolates, (draws a box with 10 written in it) okay? And we had .. 60 chocolates in total, (writes 60 at the top of the board) How many boxes would we need? L: six S: Absolutely. So, we're splitting 60 up into all the different boxes. And we'd only need six boxes, wouldn't we? L: *nods* S: Fantastic. And it's the same with this one. So, if we have 26 chocolates in every box, (rubs out 10 and writes 26) and we have 390 chocolates, (rubs out 60 and writes 390 at the top) how many boxes are we going to need?	Flexible interview

S: If I put up, if we had 52 chocolates, (rubs out 390 and puts 52 at the top) how many boxes do you think we'd need? L: Five. S: Five, okay, is that a guess? L: Yeah. S: Yeah, okay. If we had 26 chocolates, how many boxes would we need? (rubs out 52 and puts 26 at the top) L: one. S: Yeah, exactly, we'd only need one box. If we had 260 chocolates, how many boxes would we need? (puts 260 at the top) L: Ten. S: Ten, exactly, you're spot on. So, if we had 260 chocolates, that sum would have been really easy, wouldn't it? Because it'd just be 10 boxes. But it's not, it's not 260, it's 390, okay? (rubs out 260 and writes 390) So, is it going to be more or less than 10 boxes? L: More.	Flexible interview
S: Is there any number at the end here that would make it really easy to do that sum (pointing to 828) *pause*	Flexible interview
S: So Anne old five bags. How many apples did she sell? So is the answer going to be more than twelve or less than twelve? L: Less than twelve. S: Okay, so she sold this bag, (pointing to the one drawn on whiteboard) and she sold this bag (draws another), and she sold this bag (draws another), and she sold this bag (draws another). So those are all of the apples that she sold. So the question is, how many apples did she sell? So is it going to be more than twelve or less than twelve? L: More than twelve. S: More than twelve, okay.	Flexible interview

Independence Is the mediator taking a step back at appropriate points to allow the child to take over when working on tasks?

Excerpt	**Source**

S: So, okay I'm going to play a game now. What I'm going to do is I'm going to do the same thing and I'm going to hide a little pattern, and your job is to find the pattern. So we're going to take turns, I'm going to go first and make a sequence, and you're going to have to find it out, and then it's going to be your job to try to make up a sequence and try to catch me out and see if I will be able to find out what's going on.	Flexible interview
S: Now Can you come up with a sequence for me and try to see, can I figure it out? You can use these units, you can show me on the whiteboard, you can write numbers on the whiteboard and I can try and figure out. You can do it on the square, or you can do it in your copy. What would you like to use?	Flexible interview
S: I'm going to give you another little tricky one. Here you go. There's a few different ways you can figure it out. You can use these. You can take as many of these as you want. So you can do it up using that. You can have a look at our... So you can make your own plan this time, Louise.	Flexible interview
S: And again, you can use kind of whatever you like. the whiteboard, you have your copy there. Your number square and your tens and units. And I just wanted to learn a little bit about how you think about number sentences. So if you look at this for a minute	Flexible interview

Making sense Is the mediator promoting meaningfulness in the task?

Excerpt	Source
S: Okay. Do you think, Louise, there was anything that we did that you would like to do more of when you're doing maths? Can you think of anything? L: Using the whiteboard and tens and units. S: Oh yeah, okay. Great.	Student SSI

I know we drew a lot on the whiteboard. Do you find that useful to help you with your maths thinking? L: Yeah. S: Okay. And the tens and units as well, it helps, yeah? L: Yeah. S: Okay, that's brilliant. Do you think there's anything that you learnt that we did together that will help you moving forward? L: Yeah. S: Can you think about, what would it be? L: Drawing on the whiteboard.	
Louise, if you were to give me some advice for when I'm working with children again, what advice would you give me? How can I make things easier for other people that I'm working with? L: See what they like and then if it comes to those sets and sums, then they can draw what they like and do it that way. S: Okay. That's great advice	Student SSI
S: I'm going to be creative with my one. I'm going to do football scores, okay? Goals and points. Okay, (writes 1-01, 0-05, 1-03) here you go. So mine is a goal and a point, and then five points, and then a goal and three points. What's next?	Flexible interview
S: and I was thinking, it's funny that one and two are beside each other, and then you have two and three (23), which are beside each other, and then you have three and four (34), and you've got that absolutely spot on, four and five (45 for the next number). So using that logic, what would our next one be? L: Five. and eight. S: next one up from 5..? L: oh 6 S: Exactly, yeah. Five and six. And then the next one would be? L: Seven and six.. S: Yeah, the other way around though six and seven. Good on you, exactly. And another way of thinking about it is that	Flexible interview

you're actually going up one number each time
in the tens and the units, right? So if we just
took our tens Louise, (circling the first number
of each number written down on the
whiteboard)
so our first number is one, the next one is two,
then three
next one is four, and the next one would be..?
L: Five.
S: Right, and we can see that here,(Pointing to
the tens and units) one ten, two tens, three tens,
and it's exactly the same with the units, so start
off with two,
and then we go up to three, and then we go up to
four.
That makes sense.?
You can actually see it here on the hundred
square as well.
So, we've got twelve, and twenty-three, and
thirty-four, and forty-five, (moving pen and
diagonal to show the pattern)
L: fifty-six.
S: And?
L: Sixty-seven.
S: There's loads of different ways you can figure
it out.
Actually, I might just stick with that, and I
might just give you one more, and just with all
of those things you might be able to see if
there's different ways to figure it out.

If you were to look at these, Louise, is there a shortcut to figure out what the next one is instead of having to add twelve in your head? *pause*

Flexible interview

So let's take the tens first, the big long ones.
Is there something that's happening there that we can find out?
How are they changing from one to the next? (referring to the pattern of tens and units laid out by Louise beside each other)
L: umm they're going up in ones
S: Yeah, exactly.
So if you wanted to have a cheat code for the next one, how many tens would be in it at least?
L: 5
S: Yeah, exactly. So you have five of the tens.
And tell me there about the units.
L: they're going in twos
S: Exactly.
So what would the next one be? How many units?
L: nine
S: Exactly. Yeah. Fantastic job. Really, really good.
So you can see that there's different ways to do it. So you figured it out really good here (on the whiteboard), but if you visualise it like this (with tens and units), you'll be able to figure it out in a different way. Isn't that cool?
L: *nods*
S: Okay.
Lovely. Okay
Do you ever draw out maths problems like that to help you?

Flexible interview

L: *shakes head*
S: Do you think it'd help you?
L: Yeah.
S: Was it easier when you could see the boxes and see the numbers?
L: *nods head*
S: So, say for example, okay, how many players are on a football team?

Flexible interview

Do you know how many players are on your football team when you play?
L: Thirteen.
S: Thirteen, okay, good. (takes whiteboard)
So, if we have 13 players on a football team, (writes 13 on the whiteboard)
and what would we do if we had 26 players who

showed up to training? How many teams would we be able to put out? (writes 26 at the top of the whiteboard)

Pause
So, would we have enough for one team?
L: Yeah.
S: Yeah, you're absolutely spot on, we would.
Now, would we have enough for two teams?
So, we have 13 on this team, (writes 13)
but we have 26 that are coming to train.
L: Yeah.
Now, what if there's only 12 on a team, (rubs out numbers)

Flexible interview

okay, and we have
48 that come to train? (writes 48 at the top and 12 in the middle of the whiteboard in a box)
Okay, so let's see, how many teams can we make?
So, have we enough for one team?
L: Yeah.
S: You're right.
Have we enough for two teams?
L: Yeah.
S: You're right, okay, so two teams.
Have we enough for three teams?
L: Yeah.
S: You are correct
have we enough for four teams?
L: Yeah.
S: Yeah, you're absolutely spot on.
S: Okay, so enough for four teams.

Flexible interview

Brilliant. And the easy numbers here are usually multiplying by 10. So, if you had 12, say 13 in every team, (writes 13 in the box on whiteboard)
the easy one to know is if we had 130 players, (writes 130 at the top)
how many teams do we have?
L: 10.
S: Yeah, and you know that straight away because you just add a zero, don't you?
Perfect

S: Okay, now put it a bit differently. And what I want to do is, I'm going to give you... I'm going to give you a sum here. I'm going to give you an equation like what we just did. And I want you to draw a picture just like you did there to show me how to think about it. So... And I am going to say that Louise has.. four pairs of football boots and she loses.. one of the football boots. How many does she have left? So can you Draw a picture. To Show me how you would think about figuring that out. L: *draws 4 pairs of football boots, puts a cross through one pair*	Flexible interview
Makes a lot of sense, doesn't it? Do you think drawing it out helps ya? L: Mmmhm S: Okay.	Flexible interview
S: This time I'm going to say.. that the football team scored two goals and two points but the other team scored one point more How many points did the other team score?. So you can draw it out for me if you like or you can write it down. So the football team scored two goals and two points L: *writes down 2x3+2*	Flexible interview
S: Okay, we'll do just another one more. So a dog has four legs and a chicken has two legs. How many legs does two dogs and two chickens have? L: *writes 4x2+2+2=12*	Flexible interview
S: So the first team scored three goals. The other team scored some amount of goals. We don't know. But the other team lost by three points. How many goals did the other team score? L: *writes 3x3-3+6* Six.	Flexible interview
S: Sometimes, yeah. Do you find it much easier to be able to draw things and use the whiteboard? Does that help?	Flexible interview

L: yeah
S: Yeah, I think it does help you.

Monitoring Is the mediator ensuring that the child is checking his/her answers?

Excerpt	Source
L: Five..? S: So the first one is the difference between one and three, isn't it? (pointing to them on the hundred square) L: one S: Um... Between one and three, so... L: Two	Flexible interview
S: Three pairs of football boots.? L: *nods* S: Okay, really good. You did a fantastic job. And one of the little things about this sum was that Louise only lost one football boot so not a pair of football boots. So she only lost one. So how would you change your answer if she only lost one? (rubbing out the crossed out pair of boots) Show me. L: (draws the pair of football boots again and only crosses one out) S: So... What's the answer? L: Seven. S: Brilliant.	Flexible interview

Planning Is the mediator encouraging planning: showing what to do before beginning to solve the task and how to set achievable goals?

Excerpt	Source
Are you trying to look for the differences between the numbers? L: Seven. S: Seven is the difference? *Pause* What's your plan here? Are you trying to figure out the difference between the first two numbers?	Flexible interview
S: So the first one, it's how many bags, each holding 16 apples, can be filled from a box that holds 144 apples?	Flexible interview

So when you think of that, Louise, and you have to come up with some kind of an answer, an estimate, without actually doing it, what would you do? *pause* What would your plan be? *pause* L: It takes 26 chocolates to fill a box. How many boxes can you fill with 26 chocolates? *Pause* S: mm.. What's your plan here? you need to make a bit of a guess. *pause*	Flexible interview

Scaffolding Is the mediator gradually building up skills, giving less and less help until the child takes over responsibility for learning?

Excerpt	**Source**
Tell me now, what parts did you find fun and what parts did you not like? L: When I had to do it by myself I didn't really like it. And when you were helping me then I kind of liked it. S: Yeah, the first session was all on your own. I'd say that was very tough. L: *nods* S: Yeah, that's not nice.	Student SSI
Fantastic. What about this next one? (1,4,9,16,_,_,_) (L got this one wrong and wrong and wrote 24,33,43) L: Threes. S: OK, so tell me the difference between one and four is? L: Three. S: Yeah, and then you have four and nine. L: Five, S: yeah, exactly. And then you have nine and 16. L: Seven.	Flexible interview

S: Okay. L: There's two in the difference.	Flexible interview
S: There's two in the difference each time. Okay, so what's the difference between one and three? L: Two. S: And then between three and six? L: Three. S: And then between six and ten? L: Four. S: Okay, so you have two, three, four. So what's going on there?	
So, we've started here. (pencil on one on hundred square) Yeah, so we've jumped two. Okay, (moved pencil up to 3) where are we going now? To seven. (puts pencil on 3 and starts moving up each square) one, two, Three., Four. So the difference is ..? L: four S: Exactly. Okay, what's my next number?.. 13 isnt it?	Flexible interview

Do you want some help? So what's our plan? We're trying to figure out what's the difference between each one, isn't it? So, a goal and a point. So what's a goal worth? L: Three. S: Okay, so we've got a goal which is three, and this one is? L: One. S: One. Which gives you.. L: Four. S: four points.. Fantastic. So we have four here, and our next one is? L: Five. S: So our difference is? L: One. S: So you can maybe draw a little one here if you'd like to remind yourself. (between the numbers in the sequence) Good job. So this is five points, and then we have? (pointing to 1-03) L: Six. S: Yeah, exactly. So you can draw a little one there if you'd like. So if there's one on the difference here, and there's one on the difference, the next one is also going to be? L: One in the difference S: So you can draw a little one there to remind yourself. (at the end of the sequence) So if this one is, How many points? (1-03) L: Six. S: What's our next one going to be? L: Seven.	Flexible interview
S: Okay. What have you figured out there? What's between the first two, for example? L: Eleven. S: Good on you. What's the difference between the second two? L: eleven. S: Fantastic. So what do you think the difference between the third one and the fourth one will be? L: Eleven. S: Good. So you can draw in your little arc and do eleven. L: (draws arc to show 11 between the next two	Flexible interview

numbers)
S: so what does that bring us up to?
L: *writes 45*
S: Fantastic. Great job.

So can A be one?

Flexible interview

L: No.
S: Because it's too small, isn't it? Because we have to take something away to get to two, don't we?
L: It could be three.
S: Oh yeah, absolutely.
And if it was three, what would B be?
L: one.
S: Exactly. Great job. So what can A not be?
L: Two. Or one
S: well What if it was two?
Say if it was two, what would B be?
L: zero.
S: Yeah, so it can be two.
But what can it not be?
L: one.
S: Exactly.
L: Or zero.
S: Zero, correct.

How many apples are in each bag?

Flexible interview

L: 16.
S: Yeah, okay, 16 apples are in each bag.
And the question is, how many bags can you fill with 144 apples?
So.. if the question was different, and it said each bag has 16 apples, how many bags could you fill with just 16 apples? What would the answer be?
L: 16.
S: So it would just be, so 16 apples, and each bag has 16 apples.
So how many bags would you be able to fill with 16 apples?
L: two
S: If each bag can take 16 Apples.
L: umm.. one
S: Yeah, exactly.

So you knew that 10 bags would have 160 apples, so you could make that sum really easy for yourself if it was 160.

Flexible interview

So what do we know the answer is around?
L: 10.

S: Yeah, exactly, it's around 10. Fantastic, you're spot on. So is it going to be less than 10, or more than 10? L: Less. S: Yeah, so it's going to be a little bit less than 10. Fantastic, good job.	
S: So we'll just try one more of them and we'll see how we get on. So if there are 34 biscuits in a packet, how many packets can we fill up with 952 biscuits? So we have to try to make a guess. So what do we do when we try to make a guess? *Pause*	Flexible interview
S: so With 34 biscuits in each packet, if we had 34 biscuits, then how many packets would we need? *Pause* So how many biscuits are in each packet? L: 34. S: Okay, and if we have 34 biscuits, then how many packets do we need? L: One. S: Yeah, just one. So if we had 340 biscuits, how many packets would we need? L: 10. S: 10, good on you, you're dead right. So is the answer going to be more or less than 10? L: More.	Flexible interview

Sharing Is the mediator interacting in a way that communicates that he/she is on the child's side, that they are working together as a team?

Excerpt	**Source**
S: Now, so listen, today, I suppose last time you were out with me, what we did was I got you to do all the maths on your own. And today's not going to be like that. It's going to be kind of you explaining it to me a little bit and me explaining it back to you. And just talking about the maths a little bit more.	Flexible interview
So, okay we're going to play a game now. What I'm going to do is I'm going to do the same thing and I'm going to hide a little pattern,	Flexible interview

and your job is to find the pattern. So we're going to take turns, I'm going to go first and make a sequence, and you're going to have to find it out, and then it's going to be your job to try to make up a sequence and try to catch me out and see if I will be able to find out what's going on. Okay? And you can do it in any way, you can do your sequence by writing it out here (on number square), you can do a sequence by writing it or drawing it here (On whiteboard), or you can do a sequence by writing it into a copy, or you can do a sequence with these units here, and I'm going to use the units to get us started.	
And again, you can use kind of whatever you like. the whiteboard, you have your copy there. Your number square and your tens and units. And I just wanted to learn a little bit about how you think about number sentences. So if you look at this for a minute..	Flexible interview
Okay,.. so these ones are words, so they're sentences. (Opens p.82 in figure it out 5 textbook) But we have to try to write the sentences out as a sum or as an equation.	Flexible interview

Verbalising Is the mediator encouraging the child to talk aloud when doing the tasks in order to highlight their thinking?

Excerpt	**Source**
Was I asking you to do a lot of explaining about your maths? L: Yeah. S: Okay, tell me about that. Was that hard or do you think that was good? Tell me, what do you think about that? *pause* L: A little bit hard. S: Hmm. And do you prefer just to get on with your maths and not have to explain it? L: Sometimes. S: Yeah. And then sometimes, did you find it was useful? L: Yeah.	Student SSI
S: Now, so listen, today, I suppose last time you were out with me, what we did was I got you to	Flexible interview

do all the maths on your own.
And today's not going to be like that.
It's going to be kind of you explaining it to me a little bit and me explaining it back to you.
And just talking about the maths a little bit more.

S: and what's your plan when you see them? How do you approach it? What's the first thing you do? L: umm see what the count is	Flexible interview
L: Seven. S: Exactly. OK, so what's happening there?	Flexible interview
	Flexible interview
S: That one a bit trickier? L: *nods* S: So when you see something like that, talk to me. What are you thinking in terms of your plan for how you're going to do that? What's the first thing you're looking at?	
S: Tell me about this next one. (1.5,3,4.5,6,_,_,) (L got this wrong she wrote 7.5,8,9.5)	Flexible interview
So you were well able to do them. Do you find it harder to explain how you do them than it is to actually do them? L: *nods* S: Really? Okay. Do you find that with a lot of things, or just with maths? L: Just maths	Flexible interview
S: So mine is a goal and a point, and then five points, and then a goal and three points. What's next? What are you thinking?	Flexible interview
S: Do you want another one? Let's test you a little bit. (draws sequences of circles partitioned into quarters, first has one segment coloured in, then 2) Talk to me. What are you thinking? L: *starts drawing*	Flexible interview
S: Well done. Absolutely spot on. Can you describe that sequence for me?	Flexible interview

S: I'll put these over here. (brings whiteboard over) Tell me about this pattern. Whats going on?	Flexible interview
L: (starts writing numbers on whiteboard 12, 23, 34) S: Have you any ideas?	Flexible interview
L: I've never done that. S: Okay. So what do you think it means, or what do you think we have to do?	Flexible interview
S: Yeah. You actually did really well at the start. And do you know what I think helped you as well? And you've gotten really.. a lot better at it since we started. Is that you started to talk about it and you kind of talked through the thought process. And I think that was really, really good. L: *nods*	Flexible interview
S: So the first one, it's how many bags, each holding 16 apples, can be filled from a box that holds 144 apples? So when you think of that, Louise, and you have to come up with some kind of an answer, an estimate, without actually doing it, what would you do?	Flexible interview
S: Let's try another one. A bus can carry 46 passengers. How many buses are needed to carry 828 passengers? So, what are you thinking?	Flexible interview

Appendix 32

Full Outline of Pattern Matching and Thematic Analysis for Each of the Five Theoretical Propositions for Case 1 Data.

Proposition 1: MDA will Enhance Domain General Learning Functions Following the Implementation of Mediated Learning Experiences Consistent with the Theory of SCM.

Evidence of empirical patterns consistent with the structural cognitive modifiability for domain general learning functions

Does Not Do	Mediated Learning Experience	Structural Cognitive Modifiability
Okay, next one. (1,3,7,13,_,_,_) (L got this right , wrote 21,31,43) *pause* What do you think? I wonder would the number line be able to help you? How would you be able to use that to figure this one out? *Pause* **(Flexible interview 1: line 254)**	What about this one? (84,77,70,63,_,_,_) (L got this correct, she wrote 56,49,42) L; Sevens. S: Yeah, going down in sevens, isn't it? Do you know your seven times tables? Are you really good with your seven times tables? L: Not really. S: Not really? I'm only wondering because you did a really good job of that and you knew it kind of straight away and you didn't have to write it down or anything. And that's moving down in sevens, not even moving up. So, I was just wondering how you got it so quickly and so well. You did a great job with it.	S: So can you give me a sentence to describe them and what can they be and what can't they be? L: Do I write it on the board? S: No, you can just tell me if you like. Or you can write it. Would you prefer to write it? L: *nods head* L: *writes b cant be..* S: Just another couple of minutes and that will be finished. *Pause* S: Is it easier to tell me? L:*nods head* S: Okay, why don't you tell me. L: They can't be more than six.

	Did you just kind of recognise it? You just saw it? L: emm.. I noticed the 70 and the 77 and then from 63 I started counting backwards. S: Oh, OK. **Verbalising (Flexible interview 1: line 66)**	**(Flexible interview 1: line 756)**
Do you find it harder to explain how you do them than it is to actually do them? L: *nods* S: Really? Okay. Do you find that with a lot of things, or just with maths? L: Just maths S: Just with maths. Really? Okay. **(Flexible interview 1: line 308)**	So, we've started here. (pencil on one on hundred square) Yeah, so we've jumped two. Okay, (moved pencil up to 3) where are we going now? To seven. (puts pencil on 3 and starts moving up each square) one, two, Three., Four. So the difference is ..? L: four S: Exactly. Okay, what's my next number?.. 13 isnt it? S: (counts each square from 7 to 13 on number square) four, five, six. So my next difference is six. So whats going on there do you think? *pause* L: Umm going up in twos **Scaffolding (Flexible interview 1: line 281)**	*Context: a-b=2 is written on whiteboard* Can you tell me anything about A there? Is there anything that A can be and anything that A can't be? L: A can’t be one or two. **(Flexible interview 1: line 784)**

So the first one, it's how many bags, each holding 16 apples, can be filled from a box that holds 144 apples?
So when you think of that, Louise,
and you have to come up with some kind of an answer, an estimate, without actually doing it, what would you do?
pause

What would your plan be?
pause

(Flexible interview 2: line 875)

S: Yeah, exactly. Good job.
Okay, so when you see this, and you see that each bag holds 16 apples,
and we have 144 apples, how would you guess to see how, what's kind of the region of the answer, or what kind of area the answer is in?
pause

S: So, we were on this one, and we just said that, first of all, there's 26 chocolates to fill a box. How many would be filled from 390 chocolates?
And you made a good guess, you said 12.
And I wonder, can you tell me how you know that's close, or how you came to that guess?

Pause

Explaining (Flexible interview 2: line 989)

So what's the first thing you did?

L: Drawed Four pairs of football boots.
S: Okay, so four pairs of football boots. So four...
L: (writes 4)

S: whats the next bit?
L: minus one
S: The one is at the end but it's four pairs, isn't it?
So we have two in each.
How would we write that?
L: Four times two.
S: Yeah, brilliant, well done.
L: Minus one.
S: Minus one.
Equals...

L: (writes 4x2-1=7)

(Flexible interview 2: line 1408)

Do you have any way to guess?

Pause

(Flexible interview 2: line 906)

S: As in we don't know how many times 16 goes into 144. Is there any number that if it was there (pointing to 144 in the textbook), it would be easy?
pause

(Flexible interview 2: line 918)

S: Do you want to try the next one? (it takes 26 chocolates to fill a box. how many boxes can be filled with 390 chocolates?) Will you read it out for me?

L: It takes 26 chocolates to fill a box.
How many boxes can you fill with 26 chocolates?
Pause

S: mm.. What's your plan here? you need to make a bit of a guess.

pause

So how many chocolates are in each box?
pause

It's 26, isn't it?

(Flexible interview 2: line 947)

S: Let's try another one.
A bus can carry 46 passengers.
How many buses are needed to carry 828 passengers?
So, what are you thinking?

Pause

Do you want to draw them out?

pause

(Flexible interview 2: line 1064)

So we'll just try one more of them and we'll see how we get on.
So if there are 34 biscuits in a packet,
how many packets can we fill up with 952 biscuits?
So we have to try to make a guess.
So what do we do when we try to make a guess?
Pause

so With 34 biscuits in each packet,
if we had 34 biscuits, then how many packets would we need?

Pause
(Flexible interview 2: line 1185)

Proposition 2: MDA will Illustrate Reconceptualization of Maths Concepts that Follows Mediated Learning Experiences, Consistent with the Theory of SCM.

Evidence of empirical patterns consistent with structural cognitive modifiability for domain specific learning functions

Does Not Do	Mediated learning Experiences	Structural Cognitive Modifiability

The class teacher suggests Louise has had difficulties with maths since beginning school. Louise is currently having difficulty with a number of strands of the maths curriculum including number and place value, shape space and data, algebra, time and word problems. **(teacher consultation)**	So can A be one? L: No. S: Because it's too small, isn't it? Because we have to take something away to get to two, don't we? L: It could be three. S: Oh yeah, absolutely. And if it was three, what would B be? L: one. S: Exactly. Great job. So what can A not be? L: Two. Or one S: well What if it was two? Say if it was two, what would B be? L: zero. S: Yeah, so it can be two. But what can it not be? L: one. S: Exactly. L: Or zero. S: Zero, correct. **Scaffolding (Flexible interview 1: line 803)**	S: So the first team scored three goals. The other team scored some amount of goals. We don't know. But the other team lost by three points. How many goals did the other team score? L: *writes 3x3-3=* Six. S: So they scored six goals. Did they? L: No. S: What did they score? L: Two. **(Flexible interview 2: line 1476)**
Louise had some difficulty in completing equations. For more basic equations she was able to complete them accurately however for the majority she was unable to try. This will be explored in the flexible interview. **(error pattern analysis)**	So, say for example, okay, how many players are on a football team? Do you know how many players are on your football team when you play? L: Thirteen. S: Thirteen, okay, good. (takes whiteboard) So, if we have 13 players on a football team,	This time, the first team scored three goals and three points. The other team scored only goals but we don't know how many. The match ended up in a draw. How many goals did the other team score? L: (writes 3x3+3=12) *Pause* The other team scored four goals.

S: Ok, Are you going to make this really hard, really easy, or medium?
L: medium
S: Okay, thanks.
It's Friday.
L: *pause*
(writes 1, 7,15, 23)

(writes 13 on the whiteboard)
and what would we do if we had 26 players who showed up to training? How many teams would we be able to put out? (writes 26 at the top of the whiteboard)

Pause

So, would we have enough for one team?
L: Yeah.
S: Yeah, you're absolutely spot on, we would.
Now, would we have enough for two teams?
So, we have 13 on this team, (writes 13)
but we have 26 that are coming to train.
L: Yeah.
S: Yeah, so we'd have another 13 over here, wouldn't we? (writes another 13)
Fantastic.
So, we'd have enough for two teams. Would we have enough for three teams?
L: *shakes head*

Making sense (flexible interview 2: line 1078)

S: Well done, okay.
So we're in the same position. You're right, they got 12 points an four goals.

(Flexible interview 2: line 1540)

S: Wow, okay.

Okay, so the difference between these is
six, (writes 6 between 1 and 7)
the difference between these is eight,
(writes 8 between 7 and 15)
the difference between these is also eight
(writes 8 between 15 and 23)
I cant figure it out.. What's the pattern?

pause

Was it supposed to be going up in twos?
Was it supposed to be six, eight, ten?
L: yeah

(Flexible interview 1: line 360)

S: Exactly. Fantastic.
Okay, two more turns.
We'll have one, and then I'll finish up with
one, and then we'll do something different.
Okay.
Make it tricky for me now.
You did a really good job in the last one.
The last one was very tricky, actually.
L: *pauses*

writes 11, 20, 31

S: Okay, that is tricky.
Okay. So the difference here is 9 (writes 9

between first two), and 11 (writes 11
between second two)
Whats our next difference?

Pause

(Flexible interview 1: line 499)

L: *nods*
S: I'm going to write something on the whiteboard and I want you to have to think about it.
Tell me something about it. Okay, so I'm going to write this. (writes a+b=6)
Have you ever seen anything like that before?

L: ehh I’ve seen it before
S: Okay, you have.
And do you find that kind of thing very difficult, or do you like doing work like this?

L: I've never done that.
S: Okay. So what do you think it means, or what do you think we have to do?

pause
So do we know what A is? Do we know what number this is?

L: *shakes head*

S: no And we don't know what this number
is either, do we?

L: *shakes head*

(Flexible interview 1: line 672)

L: A can be one or two.
S: A can be one or two.
Will we try that out?
OK So if A is one.
And I have to take away B.
Equals two. (1-b=2)
L: three
S: So one minus three equals two.
Are you happy with that?
L: *nods head*

(**Flexible interview 1: line 787)**

Proposition 3: The MDA Procedure will Illustrate Domain General Constructs (Affective and Cognitive) that are Under-Developed, Well Developed and in the Zone of Proximal Development

Evidence of empirical patterns consistent with the zone of proximal development for domain general learning functions

Does Not Do	Does With Help	Does Independently
S: So.. if the question was different, and it said each bag has 16 apples, how many bags could you fill with just 16 apples? What would the answer be? L: 16. S: So it would just be, so 16 apples, and each bag has 16 apples. So how many bags would you be able to fill with 16 apples? L: two **(Flexible interview)**	So, say for example, okay, how many players are on a football team? Do you know how many players are on your football team when you play? L: Thirteen. S: Thirteen, okay, good. (takes whiteboard) So, if we have 13 players on a football team, (writes 13 on the whiteboard) and what would we do if we had 26 players who showed up to training? How many teams would we be able to put out? (writes 26 at the top of the whiteboard) *Pause* So, would we have enough for one team? L: Yeah. S: Yeah, you're absolutely spot on, we would. Now, would we have enough for two teams? So, we have 13 on this team, (writes 13) but we have 26 that are coming to train. L: Yeah. S: Yeah, so we'd have another 13 over here, wouldn't we? (writes another 13) Fantastic. So, we'd have enough for	This time, the first team scored three goals and three points. The other team scored only goals but we don't know how many. The match ended up in a draw. How many goals did the other team score? L: (writes 3x3+3=12) *Pause* The other team scored four goals. **(Flexible interview)**

two teams. Would we have enough for three teams?
L: *shakes head*

(Flexible interview)

S: Ok, Are you going to make this really hard, really easy, or medium?
L: medium
S: Okay, thanks.
It's Friday.
L: *pause*
(writes 1, 7,15, 23)

S: Wow, okay.

(Flexible interview)

Pause
S: What's your plan here?
Are you trying to figure out the difference between the first two numbers?

L: Five..?
S: So the first one is the difference between one and three, isn't it? (pointing to them on the hundred square)
L: one
S: Um... Between one and three, so...
L: Two

(Flexible interview)

So, say for example with this bus one, okay, we have 46 passengers on the bus.
That's how many can fit on one bus.
And we have 828 passengers altogether.
And here's our bus. (draws a bus on the whiteboard)
And on the bus there are 46. (writes 46 on the bus)
And we have 828. (writes 828 at the top)
So, is it going to be more or less than 10?

L: less

(Flexible interview)

S: It's going to be less than 10, why do you say that?
Pause
So, if there was 10 buses, how many would we bring?
L: 46.
S: So, 46 is there, how many

S: Divide, yeah, I think you're right.
L: (writes 7 divided by 56)

S: So is that the right way around?
Can we divide a bigger number into a smaller number?
L: No,
S: It’s the other way around isn’t it?.
L: (writes 56 divided by 7)

(Flexible interview)

buses?
L: one
S: Yeah, so if there was 10 buses, how many?
pause
L: 10.

(Flexible interview)

Proposition 4: The MDA Procedure will Illustrate Domain Specific (Maths) Constructs that are Under-Developed, Well Developed and in the Zone of Proximal Development

Evidence of empirical patterns consistent with the zone of proximal development for domain specific learning functions

Does Not Do	Does with Help	Does Independently
Fantastic. What about this next one? (1,4,9,16,_,_,_) (L got this one wrong and wrong and wrote 24,33,43) L: Threes. **(Flexible interview)**	What about our next one down here? (1,4,10,19,_,_,_) (L got this one wrong and wrote 30,42,53) Can you see them okay? L: *nods* *pause* L: Three. *pause* S: The difference is three in the first one. Is that what you mean? Ok what about the next one? *pause* You can use this to help if you like (hands number square) you can have the tens and units there if you like. L: Six. S: Yeah, six is the next one. L: Nine. S: Okay, so what's happening? L: going up in Three. **(Flexible interview)**	S: So, just for this one, you might be able to explain it to me because you got so many of them right. But what was the did you do with this one? (8,16,24,32,_,_,_,) (L got this correct and wrote 40, 48, 56) L: Eights **(Flexible interview)**

Proposition 5: MDA will Provide Practical Information to the Teacher in Relation to the Student informed by Theories of ZoPD and SCM

Thematic analysis of teacher and SET semi structured interviews

Expectations for External Support
Teacher: Yeah, there are a lot of difficulties, definitely, I suppose, you know, like, people come in, they do an assessment on a child, you know, they tell you what needs a child has, but then often it's, okay, you know, here's their needs, off you go now and figure it out yourself, and that happens a lot of times, that we need more support in that sense, that we need to be told, well, you know, try this with them, or try that with them, or this will work best for that child, and sometimes we feel a bit isolated in the sense that we're not getting enough support there Researcher: Brilliant, have you had input from NEPS before with regards to maths difficulties, can you remember, you might not have? Teacher: I, know, I have once actually, not with maths difficulties actually, no, no I haven't, okay, no personally, I haven't worked with any, Teacher: So I suppose whatever assessments, whatever needs you identify, the communication between the classroom teacher of what you found and guidance going forward, so sometimes, as we said earlier, it's just you get a score and it's left as that, so like loads of support from there on, you know, what can I do, what can I implement in my classroom, have you come across this elsewhere, is there anything that works for you, is there anything you could tell us for our teaching? SET: Well, how can they help us best support that pupil? Because we'll have tried as much as we can within our setting. So that's really, I suppose, that's why we reach out to anybody. SET: Well, if it gives us information and it gives us support, how can we best help? Like it's all good and well doing assessments, but where do you go from there? You know, so recommendations, they're what teachers need. Like we're very busy people and especially in a school like this where there's four classes in one room. You know, we haven't got the time to invest and we care for every pupil and we want the best from everyone. But, you know, when we go and reach out for help, that I think is the sort of invaluable. You need practical advice of what to do. SET: So I think coming back to teachers with supports or coming in and overseeing an intervention for a period would help teachers because, as I said, you know, maths is only one of many, many subjects that we have to get through. And I think that's the sort of thing that, you know, practical, hands-on, useful support that would support the teachers and something like that where, you know, maybe they could model this as a good practice to use

Contact time
Teacher: Well, I suppose like the length of time you can give is obviously another difficulty, so like, you know, what can you really bring to a child in two, three sessions

really, you know, it's very hard for them, you know, if you ask me have I noticed any difference, any changes lets say, or if I noticed any progression with Louise, I'd say it's very hard in two or three sessions to make a massive impact, so that may be going forward, it would have to be over a longer period of time,
you know, maybe a couple more sessions might have a greater impact in the future.
Even for her, I know, you know, she's coming in, she's meeting you, but just definitely for her even, the more times she sees you, it's going to be a benefit for her.

SET: Yeah, no, it's definitely beneficial. But I mean, coming in three times, it's probably not enough. You have to build relationships as well, but definitely any help that NEPS or whoever could offer a school would be welcomed.
But it would be maybe better if it was more structured for a longer period, like an intervention of six weeks or whatever.
SET: It'd be more intensive and I suppose it would help build the relationships because lots of these kids struggle socially and emotionally too, you know, so maybe that's something to be considered.

Teachers observing the sessions

Teacher: Maybe even actually, so we'll say, you know how you would have taken out a child and done a little bit of work, it might be a benefit for a class teacher to even go in and observe what you're doing, so we'll say you might have some sort of strategy that works well for the child that I can bring into my teaching

SET: Well, this would be a good strategy to use, you know, because obviously you were here and you were working away, but we have just the report to see what you were doing, you know, so, you know, if we even could shadow you maybe for a while or something like that.

Appendix 33

Thematic Analysis of Domain General and Domain Specific Learning Functions for Case 2 Data (Sarah). Definitions are Derived from Checklists at "Learning resources": https://www.dynamicassessmentuk.com. See Appendix 21.

Thematic Analysis of Cognitive Learning Functions

Recognition Is the child able to recognise when answers are incorrect?
Reflectiveness Is the child pausing to reflect on their answers?

Evidence	Source
Researcher: Have a look at this one *writes 16+16* Sarah: *counts out 5 tens rods* I need a little bit more tens. Researcher: You need more tens? (clicking) - Okay. Sarah: *counts out 6 tens rods and 3 tens rods, puts them together and starts counting them* *looks at the materials and pauses* Researcher: How are you getting on? Are you getting stuck? Sarah: - Yeah.	Flexible interview
Researcher: Well, okay. So we have 16 and 16. So we did a great job before of making up the numbers. And with the first 16 there, how many tens do we need with 16? Sarah: Six.	Flexible interview
Researcher: So close, I think it's 22. So 10 plus 12 is 22 and then our next 10 is. Sarah: *counts blocks of the 10s rod* 30!	Flexible interview
(14+8) *starts counting 8 units* Researcher: So, you can tell me what you're doing Sarah. What's the first job you're doing? Sarah: I was getting 8 units Researcher Oh, it's a really good plan, I like that. What's your next job? Sarah: *gets 4 tens*	Flexible interview

Context: counting out 14+18 using concrete materials Researcher: Well done. What's our next job? Sarah: add them all up Researcher: can You show me that? Sarah: *counts each of the units and counts one for each 10* 13!	Flexible interview
(13+8) Sarah: *writes it out in columns with t and u for tens and units at the top* Researcher: Oh, fabulous. So what's the next job? Sarah: *writes zero underneath the units column and carries the 1, then writes 3 under tens column* Thirty!	Flexible interview
Researcher: Okay, so now we have our two 16s. And if we can mix them up and get the answer what do you get. Sarah: *counts the 12 units and the two tens rods* - 14. Researcher: 14? How did we get that? Okay. Sarah: I don't know	Flexible interview
Sarah: Add them up. Researcher: Oh, okay. Can you show me? Sarah: *brings both piles together 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16. (counts each of the units individually and counts some blocks on the 10s rod)	Flexible interview
Sarah: *writes 16-6* Researcher: equals. Sarah: * starts counting backwards quietly while using fingers to keep track* 12	Flexible interview
In fact, I'm going to change that. (writes 12+13) You can tell me how you're doing it. Sarah: *gets 1 ten and 2 units, and gets 3 tens and 1 unit)	Flexible interview
Researcher: Okay. Which number is which? Can you show me which number is which down here? Sarah: This one is twelve (one ten and 2 units) and this one is thirteen (3 tens and one unit). Researcher: Okay, fantastic. So, this one is twelve because you have one ten	Flexible interview

and two units, right? Sarah: Yeah. *starts making a change to the other pile and puts one ten and 3 units*	
Okay, so what's our next job? You have twelve here and thirteen here. Sarah: Count them all up. Researcher: Okay, can you show me how you do that? Sarah: *counts every unit and each block of the 10 rod* 27! Researcher: You did loads of counting there, didn't you? Sarah: Yeah.	Flexible interview
Sarah: *gets 2 tens and 2 units* Researcher: Good job. Okay, so you have 22. And how many do you have to take away? Sarah: Eleven. Researcher: Okay, can you take away eleven? Sarah: *counts the units and the tens rods as one* All gone! Researcher: All gone?	Flexible interview
Researcher: Sarah, this is your new number. Ready? I'm going to get you a new number. (gives 2 tens and 21 units) Sarah: *counts units individually and writes 39* Researcher: ok lets count Forty..? Sarah: One.	Flexible interview
Researcher: Okay. Good job. Well done. Can I give you a different one? Sarah: Yeah. Researcher: *writes 13-9* Sarah: Okay. So what's the first thing you have to do? Sarah: *writes 6 in units, then writes 5 in tens*	Flexible interview

Communication Is the child communicating their answers in a clear and coherent manner?

Evidence	**Source**
S: What's so hard about the tens and units? Do you know? Sarah: No.	Student SSI

S: Well, that's really good. If you had to change anything, about our maths, what would that be? Sarah: Nothing. S: Would you change anything about the maths that you do in class? Sarah: No.	Student SSI
And when you were explaining it, did that make it easier to understand? Sarah: No. S: So it was just easier to do it and not have to explain it. And was explaining it nearly slowing you down? Sarah: A little bit. Yeah.	Student SSI
Researcher: 22! How did you get that? You're so clever because you're right to use these, *referring to tens rods* that's a great job. And how did you put them together? Can you explain it to me? Sarah: I just put that one there and these with the other 10 *referring to the two groups she made*. Researcher: And then you mash them together again? Sarah: Yeah.	Flexible interview
Researcher: Okay, so now we have our two 16s. And if we can mix them up and get the answer what do you get. Sarah: *counts the 12 units and the two tens rods* - 14. Researcher: 14? How did we get that? Okay. Sarah: I don’t know	Flexible interview
Sarah: *counts the 13 units, then places a tens rod with three units* Researcher: Can you write the number for me? Sarah: yeah *writes 13* Researcher: Wow, well done, you got that spot on, well done. How did you know that you could show it to me like this? *referring to one 10 rod and 3 units* Sarah: I don't know.	Flexible interview
Researcher: did you get that in your head? Sarah: *nods Researcher: How did you get that in your head? Can you explain? Do you have any idea how you got that? Sarah: I don't know.	Flexible interview
Sarah: *counts units, but doesn’t count blocks on 10 rod, writes 21 Researcher: Well done.	Flexible interview

How did you get that? Can you tell me how you did this? That was really good. Sarah: I don't really know. Researcher: And how many oranges are there? Sarah: Six.	Flexible interview
Researcher: OK, so how many more tomatoes are there than oranges? So, what's the question asking us? Sarah: I don't know	

Thematic Analysis of Domain Specific Learning Functions

Place value

Evidence	**Source**
Sarah is currently having difficulties with multiple strands of the maths curriculum. The class teacher suggests she has difficulty with numeracy in general. She suggests Sarah has appears to have some understanding of elements of numeracy such as place value	Teacher consultation
however there may be some difficulty with multi-step problems, potentially related to executive functioning, working memory or concentration.	Teacher consultation
The next part of the abstract level assessment was in the area of place value. It can be seen from Figure 2 that Sarah got a lot of these questions wrong. There is no obvious error pattern here that would be suggestive of a certain type of misconception. Perhaps Sarah was unsure of what was being asked of her here. Sarah's conception of place value will be explored in the abstract level assessment.	Error pattern analysis
S: Okay. If I was to do this maths with another student, have you any advice for me? How should I help people with their maths? What did you find useful? Sarah: Doing the T and U and then writing the sum under. S: Okay. Is that the way you find it easiest? Sarah: yeah	Student SSI

Researcher: Okay, so now we have our two 16s. Flexible interview
And if we can mix them up and get the answer
what do you get.
Sarah: *counts the 12 units and the two tens
rods* - 14.
Researcher: 14? How did we get that? Okay.

(14+8) Flexible interview
Sarah: ok
starts counting 8 units
Researcher: So, you can tell me what you're
doing, Sarah. What's the first job you're doing?
Sarah: I was getting 8 units
Researcher Oh, it's a really good plan, I like that.
What's your next job?
Sarah: *gets 4 tens*
Researcher: Well done. What's our next job? Flexible interview
Sarah: add them all up
Researcher: can You show me that?
Sarah: *counts each of the units and counts one
for each 10*
13!
Okay, so we have eleven. So then we wrote Flexible interview
down our one.
And when we have eleven, do we have enough
to go to the shop to swap it for a big ten?
Sarah: No.
Researcher: Oh, we don't? Flexible interview
Okay, so how many do we need to go to the shop
to swap for a big ten?
Sarah: Eighteen.

Researcher: So, I'm going to show you this one Flexible interview
and you can take your tens and units and show
me if you couldn't write it out the way you did
before, which was lovely, can you do it with the
tens and units?
In fact, I'm going to change that. (writes 12+13)
You can tell me how you're doing it.
Sarah: *gets 1 ten and 2 units, and gets 3 tens Flexible interview
and 1 unit)
Researcher: Okay, can you tell me what exactly
you've done there?
Okay, so what's our next job? You have twelve Flexible interview
here and thirteen here.
Sarah: Count them all up.
Researcher: Okay, can you show me how you do
that?
Sarah: *counts every unit and each block of the
10 rod*

27!
Researcher: You did loads of counting there, didn't you?
Sarah: Yeah.

Good job. Okay, so you have 22. And how many do you have to take away?	Flexible interview

Sarah: Eleven.
Researcher: Okay, can you take away eleven?
Sarah: *counts the units and the tens rods as one*
All gone!

Appendix 34

Thematic Analysis of Mediated Learning Experiences for Case 2 Data. Definitions derived from Checklists at "Learning resources": https://www.dynamicassessmentuk.com. See Appendix 22.

Encouraging Is the mediator giving frequent, enthusiastic praise and encouragement in a way that provides valuable feedback to the child?

Excerpt	Source
Sarah: *uses a 10 rod and 2 units Researcher: Oh, wow. How do you know to use this for these straight away? *referring to 10s rod* Have you done that before? Sarah: Yeah. Researcher: That's really clever well done? Makes it a lot easier, doesn't it?	Flexible interview
So, let's look at this one. *writes 5+6* Sarah: *counts out 5 units, then counts out 6 units in separate piles* I'm done Researcher: Okay, what's the answer? Sarah: *counts each unit in both piles* 11! Researcher: 11! Well done.	Flexible interview
Researcher: Yeah, it was really clever. So you took out your 10 units and you gave it this one here *the 10 rod*. And that's a neater way to have it, isn't it? Well done, good on you. That's such a good skill, I'm so impressed with that. Okay.	Flexible interview
Sarah: *counts the 13 units, then places a tens rod with three units* Researcher: Can you write the number for me? Sarah: yeah *writes 13* Researcher: Wow, well done, you got that spot on, well done.	Flexible interview
Researcher: well done Now, this is the tricky part coming up. You have 8 and you have 14. What's your next job? Sarah: To get the answer. Researcher: Mm, so what are you gonna do? Sarah: *starts counting the individual blocks of the tens rod*	Flexible interview

22! Researcher: 22, and that is fantastic. Sarah: to get, to count up the other number Researcher: Good job. What's our other number called? Sarah: 18 Researcher: Can you show me that? Good job. Well done. Okay. How many tens are in 18, first of all? Sarah: One. Researcher: Perfect. Well done. And how many units? Sarah: Eight. Researcher: good on ya	Flexible interview
Researcher: You did great work for me last week, do you know? You were fantastic. And I found it really interesting. Learning a little bit more about the tens and units. Because I think you did great work with that.	Flexible interview
Researcher: Thirty. And come here, you didn't count every single one then, did you? Sarah: No. Researcher: How did you do it then? Sarah: Because I just know three tens make thirty. Researcher: Hey, that's exactly right. Great job.	Flexible interview
Researcher: Oh, that's a really, really good plan. So how many tens are there? Sarah: 40. Researcher: 40, exactly. So now you're able to say 46 (writing it on whiteboard) And that saves you all of that counting, doesn't it? Sarah: Yep. Researcher: Well done. That's really, really good.	Flexible interview

Explaining Is the mediator asking for explanations, guiding the child to justify their answers?

Excerpt	Source

S: No. did you find it easy or did you find it hard to explain about the maths and explain how you were doing the maths? Sarah: A little bit of both. S: Oh, a little bit of both. Okay. And when you were explaining it, did that make it easier to understand? Sarah: No.	Student SSI
S: So it was just easier to do it and not have to explain it. And was explaining it nearly slowing you down? Sarah: A little bit. Yeah.	Student SSI
Ok look at this one can you make that for me? *writes the number 12* Sarah: *uses a 10 rod and 2 units Researcher: Oh, wow. How do you know to use this for these straight away? *referring to 10s rod*	Flexible interview
Sarah: *counts each unit in both piles* 11 Researcher: 11! Well done. Can you tell me how you figured that out? Sarah: I just grabbed, I just got some fives and six, and I put them all together. Researcher: and then you mashed them all together, did you? And then how did you do it then, what did you do? Sarah: I just counted them.	Flexible interview
Researcher: whats the answer? Sarah: 22 Researcher: 22! How did you get that? You're so clever because you're right to use these, *referring to tens rods* that's a great job. And how did you put them together? Can you explain it to me? Sarah: I just put that one there and these with the other 10 *referring to the two groups she made*.	Flexible interview
Researcher: Then when you put them together like that, which was a great job. How did you know that was 22? Sarah: I don't know. (laughing) Researcher: Did you have to count every one of these? *referring to the individual blocks in the	Flexible interview

10s rod* Sarah: Yeah.	
Sarah: *counts the 12 units and the two tens rods* - 14. Researcher: 14? How did we get that? Okay. Sarah: I don't know	Flexible interview
Sarah: yeah *writes 13* Researcher: Wow, well done, you got that spot on, well done. How did you know that you could show it to me like this? *referring to one 10 rod and 3 units* Sarah: I don't know.	Flexible interview
Sarah: * touches each of the oranges and pears in the book with her pencil and counts, writes 6+14=20* Researcher: did you get that in your head? Sarah: *nods Researcher: How did you get that in your head? Can you explain? Do you have any idea how you got that? Sarah: I don't know.	Flexible interview
Researcher: Were you? Fantastic job. And tell me, when you were doing it, did you start at the big number or did you start at the small number? Sarah: The small number. Researcher: Oh, you started at the small number. So can you tell me what you did then? Sarah: So I counted the oranges and then counted all the pears. Researcher: Oh, so you actually counted them here on the book. Okay, great job.	Flexible interview

Explicit help Is the mediator having to give detailed feedback/assistance including explicit discussion of strategies in order to improve performance?

Excerpt	**Source**
So, the first thing you did was count the units. So, do you know how what you did before (pointing and referring to the concrete tens and units), which was correct, and you counted everything all together here (referring to the fact she counted each block of the tens) What we could do is we could just count the units over here (pointing to the units). So, watch me here. So, you go bring all the units	Flexible interview

together and then you have, look, one, two, three, four, five (pointing to each unit).
So, then that's exactly what you did here (pointing to the units column on the whiteboard) because they're your units, aren't they?
Okay, so you can write in your five for me.
Sarah: *writes 5 under units column*
And if we have five units, what's our next job? The one you did over here (points to tens column).
Sarah: Count up two tens.
Researcher: Exactly. Okay, so look over here. (pointing to the two tens rods)
We have one ten and we have two tens.
And you wrote in your two, which you were absolutely right.
And what's our answer then?
Sarah: Twenty-five.
Researcher: Good job, exactly.

Independence Is the mediator taking a step back at appropriate points to allow the child to take over when working on tasks?

Excerpt	**Source**
And you can write it out on your book if you like it. Or you can maybe use these again *referring to tens and units* or you can use your number square. Just tell me how you'd like to do it. So, let's look at this one. *writes 5+6*	Flexible interview
Researcher: Let's practice that one again and do something a little different. I'm going to ask you to write it out for me. Can you write thirteen, plus eighteen. Sarah: *writes 13+18 Now you can do this any way you want. You can use anything. You can use your copy, you can use your number square, you can use these (tens and units).	Flexible interview

Making sense Is the mediator promoting meaningfulness in the task?

Excerpt	Source
Sarah: It was all very easy. S: That's brilliant. What was your favourite thing about the maths that we did together?	Student SSI

Sarah: The tens and units. S: Okay.	
Researcher: and what can we swap these for? Sarah: the ten *picks up the ten rod* Researcher: the ten, so we can take another ten *gets another ten rod* and now we have the best way of showing 22 haven’t we? Sarah: yeah Researcher: whats that like Sarah? Do you know when you take those ten there and you can swap them? Whats that like? Sarah: I don’t know Researcher: , It's a little bit like going to the shop where you can have ten of them and you swap it in for something else, that's the same. Sarah: Yeah. Researcher: A little bit, isn't it? Yeah	Flexible interview
Researcher: Now, let me see. So do you know what I liked about what you were saying before the break? It was about going to the shop and swapping in your ten little ones and getting one big ten. So that was really, really interesting. And I want to learn a little bit more about that	Flexible interview
Researcher: Good job. Now, do you need to go to the shop with those? Or is that the best way you can show me? What do I mean by that? Do you remember what we said That if you have ten of these little fellas (referring to units).	Flexible interview
Sarah Yeah. Researcher: Yeah. (starts counting) One, two, Sarah: three, four, five, six, seven, eight. Eight. Researcher: So we need a couple more. Nine, ten. So we have ten there. What can we do with that? Yeah, we can go to the shop with them so we can get rid of them. And we can get in? Sarah: A ten.	Flexible interview
Researcher: Good job. So because there was more than ten, you had to go to the shop, swap out your little ones, get in this big one, and then you were ready. Sarah: yeah	Flexible interview
Researcher: And is that the best way to show thirteen? Can you go to the shop? Do you have enough to go to the shop?	Flexible interview

Sarah : yeah
Researcher: If you want to go to the shop, what do we do?
Sarah: We swap it.
Researcher: Okay, for how many?
Sarah: Ten.
Researcher: Yeah, okay.

Sarah: *brings both piles together 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16. (counts each of the units individually and counts some blocks on the 10s rod) Researcher: Sixteen. So you were right. You have your ten units here, and when you have your ten units, do you have enough to go to the shop to swap it? Sarah: Yeah.	Flexible interview
Do you remember you did this, and you said, oh, that's fourteen, and then I asked you, is there a better way to do fourteen, and you said, yeah, there is, and then you swapped out these ten (ten units), and you brought in this. And that's a lot neater, isn't it? Sarah: Yeah. Researcher: Is there any clue with this number (pointing to 14 written down) that tells us there's an easier way to do it? Sarah: I don’t know: Researcher: Sometimes, Sarah, well all the time, if the number has two numbers, the first one is always the.. Sarah: Same. Researcher: The first one is the ten, and the second one is the units. So to save ourselves time, we can just get out the ten, and get out our units. Sarah; Yeah.	Flexible interview
Researcher: Do you prefer to do sums when you write them down with numbers, or do you prefer to do them with the tens and units? Sarah: tens and units. Researcher: Do you? Sarah: Yeah. Researcher: So is it harder or easier to understand when you're doing this (tens and units) or with the numbers? Sarah: It's easier with this. (tens and units)	Flexible interview

Researcher: It's easier with the tens and units.
OK.
Thank you for that.

Flexible interview

S: So, the first thing you did was count the units. So, do you know how what you did before (pointing and referring to the concrete tens and units), which was correct, and you counted everything all together here (referring to the fact she counted each block of the tens)
What we could do is we could just count the units over here (pointing to the units).
So, watch me here. So, you go bring all the units together and then you have, look, one, two, three, four, five (pointing to each unit).
So, then that's exactly what you did here (pointing to the units column on the whiteboard) because they're your units, aren't they?
Okay, so you can write in your five for me.

Flexible interview

Sarah: *writes 5 under units column*
And if we have five units, what's our next job? The one you did over here (points to tens column).
Sarah: Count up two tens.
Researcher: Exactly. Okay, so look over here. (pointing to the two tens rods)
We have one ten and we have two tens.
And you wrote in your two, which you were absolutely right.
And what's our answer then?
Sarah: Twenty-five.
Researcher: Good job, exactly.

Flexible interview

Researcher: Sarah, have a look at this.
Can you count in tens for me, Are you able to count in tens?
Sarah: Yeah. Ten, twenty, thirty, forty, fifty, sixty, seventy, eighteen, nineteen, ninety, a hundred.
Researcher: Wow, that's exactly right. Well done.
So, you can count up in tens.
Sarah: Yes.

Flexible interview

And I'm going to give you these (holding tens rods). I just want you to tell me what the number is. Okay.
Sarah: Ok
Researcher: So, I'm going to test you. Are you ready?

Sarah: Yes. Researcher: And how many is that? (three tens) Sarah: Thirty. Researcher: Thirty. And come here, you didn't count every single one then, did you? Sarah: No. Researcher: How did you do it then? Sarah: Because I just know three tens make thirty.	
Okay, so when can we use those skills, Sarah? Sarah: by counting Researcher: So, remember we're doing sums. And we have, for example, twenty-five plus twenty-one (writes it on the whiteboard). What we can do, Sarah, is we can use our tens and units, so we can do 25 like this, (putting 5 units and 2 tens rods out) and we can do 21 like this, (putting 2 tens rods and one unit out) and here's our tens and here's our units (pointing to columns written on whiteboard) and we can take our units and put them together (taking the concrete units and putting them together), and that makes 6, doesn't it? (writing 6 under the units column on the whiteboard) Sarah: Yep.	Flexible interview
Researcher: And we have 2 sets of 10, I've got 2 sets of 2 of 10, and would you now, to add these up, Sarah, would you count up every single one? (pointing to each block of the tens rod) Sarah: No. Researcher: so how would you do it? Sarah: Just by knowing all the 10s what it makes up Researcher: Oh, that's a really, really good plan. So how many tens are there? Sarah: 40. Researcher: 40, exactly. So now you're able to say 46 (writing it on whiteboard) And that saves you all of that counting, doesn't it?	Flexible interview
Researcher: Oh, so we carry the one. And what does that look like if you were to do it with this? (pointing to the 11 units) Sarah: I don't really know. Researcher: Do you want me to show you? Can I have that? (hands units to me) Oh, good. Thank you. So you have 11 here, right?	Flexible interview

One, two, three, four, five, six, seven, eight, nine, ten, 11. And we don't write down 11 because that's too many units. Sarah: Yeah. Researcher: So when we have ten units, we can swap them. So we have a ten here and we have two tens here (referring to the tens rods left from the two piles). And we can leave our units here. So we can swap these ten (ten units) for a big ten. Sarah: Yeah. Researcher: That's what you're doing. When You're carrying the one. (pointing back to the whiteboard with the column) Okay?	

Monitoring Is the mediator ensuring that the child is checking his/her answers?

Excerpt	**Source**
Researcher: How are you getting on? Are you getting stuck? Sarah: - Yeah. Researcher: Well, okay. So we have 16 and 16. So we did a great job before of making up the numbers. And with the first 16 there, how many tens do we need with 16? Sarah: Six. Researcher: Oh, so, I think we could use maybe six of the units, could we? Sarah: Yeah.	Flexible interview
Researcher Oh, it's a really good plan, I like that. What's your next job? Sarah: *gets 4 tens* Researcher: Oh 4 tens, So, what's your next number? It's 14 isn't it? Sarah: Yeah. Researcher: Okay, so is the, which one is the units and which one is the tens? Sarah: That's the units and that's the tens. *points to the 1 and the 4 respectively* Researcher: Oh, okay. So, you need 4 units and how many tens? Sarah: One.	Flexible interview

Researcher: you have one ten and how many units? Sarah: *counts*. – 8 Researcher:. - You're getting a bit mixed up 'cause they're all jumbled together. Sarah: Yeah Researcher: So, it's a good idea of what how it is to move into one side like that. So, give it another go	Flexible interview
Sarah: *counts each of the units and counts one for each 10* 13! Researcher:. So, the first thing you did when you were counting them, was to count the units wasn't it? that was a good plan, and you found that there was how many units?	Flexible interview
Researcher: Oh, well done. Can you show me the best way to show me thirteen? Sarah:*puts the ten rod with the 3 units* Researcher: And is that definitely thirteen? Sarah: Yeah.	Flexible interview
Sarah: *writes zero underneath the units column and carries the 1, then writes 3 under tens column* Thirty Researcher: Let's check our answer. So three, eight plus three, what's eight plus three? Sarah: Ten. Researcher: So we have eight, nine, ten, eleven. Okay, (rubs out 0) so we're going to swap that one out and put in a..? Sarah: *writes 1* Researcher: good job.	Flexible interview
Sarah: This one is twelve (one ten and 2 units) and this one is thirteen (3 tens and one unit). Researcher: Okay, fantastic. So, this one is twelve because you have one ten and two units, right? Sarah: Yeah. *starts making a change to the other pile and puts one ten and 3 units* Researcher: Ok and youre making a little change, this one is going to be thirteen.	Flexible interview

Planning Is the child using a plan or strategy to solve the problem?

Evidence	**Source**
Researcher: So, you can tell me what you're doing, Sarah. What's the first job you're doing? Sarah: I was getting 8 units Researcher Oh, it's a really good plan, I like that. What's your next job?	Flexible interview
Researcher: well done Now, this is the tricky part coming up. You have 8 and you have 14. What's your next job? Sarah: To get the answer. Researcher: Mm, so what are you gonna do? Sarah: *starts counting the individual blocks of the tens rod* 22! Researcher: 22, and that is fantastic.	Flexible interview

Scaffolding Is the mediator gradually building up skills, giving less and less help until the child takes over responsibility for learning?

Evidence	**Source**
Researcher: Well, okay. So we have 16 and 16. So we did a great job before of making up the numbers. And with the first 16 there, how many tens do we need with 16? Sarah: Six. Researcher: Oh, so, I think we could use maybe six of the units, could we? Sarah: Yeah. Researcher: Okay, so lets count out 6 units. – Sarah: *counts them out* Researcher: Good job. Now how many of the tens goes with the units? Sarah: *moves one tens rod over to the 6 units* Researcher: good job. Now can we do the same thing for the second 16. Sarah: *counts out second 16 with one ten and 6 units Researcher: Okay, so now we have our two 16s. And if we can mix them up and get the answer what do you get.	Flexible interview
Researcher: so you did really well you counted the units first, so we put the units to one side *moves the groups of units together* and we go one, two, three, four, five, six, seven, eight, three, four, five, six, seven, eight, nine, 10, 11, 12. And then we have 10 *referring to the first 10s	Flexible interview

rod*. So what's 12 plus 10
Sarah: *counts on from 12 pointing to each block of the 10s rod*
21
Researcher: So close, I think it's 22.
Sarah: Yeah. Flexible interview
Researcher: I like your plan.
Sarah: And then I get eight units.
Researcher: Okay.
So, is our first number, what's number called?
Sarah: Fourteen.
Researcher: Okay. So, 14 made up of four units, and how many tens?
Sarah: One.
Researcher: Okay.
Can you show me that?
Sarah: * gets one ten and 4 units*
Researcher: Good job. Now whats our next job?
Sarah: to get, to count up the other number
Researcher: Good job. What's our other number called?
Sarah: 18
Researcher: Can you show me that? Good job. Well done. Okay.
How many tens are in 18, first of all?
Sarah: One.
Researcher: Perfect. Well done. And how many units?
Sarah: Eight.
Researcher: good on ya
Researcher: Well done. What's our next job?
Sarah: add them all up
Researcher: can You show me that?
Researcher: Okay. Flexible interview
So, is that the best way that we can do twelve? Is there a better way? *pointing to the units*
Sarah: *gets a 10 rod from the other addend and 2 units*
Researcher: Oh, exactly. So, these are the two that we already had,(tens rods) so we're just taking another one to do that (taking another 10 rod from the box). So, when you went to the shop, and you swapped out your ten (moves 10 units away), and you got a big ten, didn't you?
Sarah: Yeah.
Researcher: Because they're the same. Well done. So, now we are left with how many units? Sarah: Two.
Researcher: Okay, we've only two units left, so that's the first part of our attempt. How many tens

have we got here?
Sarah: Three.
Researcher: three
So what is the answer?
Sarah: 32.
Researcher: Yeah. (starts counting) One, two, Flexible interview
Sarah: three, four, five, six, seven, eight. Eight.
Researcher: So we need a couple more. Nine, ten.
So we have ten there. What can we do with that?
Yeah, we can go to the shop with them so we can get rid of them.
And we can get in?
Sarah: A ten.
Researcher: Fabulous. So that's our first number? Flexible interview
How do you get our first number?
Sarah: *counts 8
I've got 8 here
Researcher: Eight.
Eight units, is it?
Okay, so that's our eight units.
And how many tens do we need?
Sarah: One. *gets one ten*
Researcher: Okay, so let's get our one ten. Perfect, so we can put that to one side.
Good job, Sarah.
So that's that number done. can we get our other number?
Sarah: We need
two more tens.
Researcher: Two tens?
Oh, for this one? *points to the number 13*
Sarah: Three tens will make 30.
Researcher: Yeah.
Well, I want you to show me how you did the addition first. So I can take these away (the three tens).
So you did that one first. (18)
And you have your eight units. So that's your eighteen.
So you can move that to one side.
And now our next job is to find this number, (points to 13).
So you can get your numbers together.
And now we need to find thirteen. So how many units are in thirteen?
Sarah: Three.
Researcher: Fantastic. And how many tens do you want?
Sarah: One.

S: So, now, what's our first job when we're adding these together? (referring to the two separate piles) Sarah: You count them. Researcher: Would you add the tens or would you add the units first? Units. Sarah: Units. Researcher: Okay, so let's get our units together.	Flexible interview
S: can you show me how that would look if we did that with our tens and units? So what's our first job here? What's the first job we have to do? Can you Tell me what you're doing. Sarah: *starts counting the units* Getting the tens, getting six, and then... Researcher: There's six units, aren't there? Sarah: Then get fourteen. *counts 14 units*	Flexible interview
Sarah: *brings both piles together 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16. (counts each of the units individually and counts some blocks on the 10s rod) Researcher: Sixteen. So you were right. You have your ten units here, and when you have your ten units, do you have enough to go to the shop to swap it? Sarah: Yeah. Researcher: Lovely. Okay, so can you swap these? (pointing to the 10 units) And how many tens do you get for that? Sarah: two Researcher: You get one big ten, don't you? Sarah: Yeah.	Flexible interview
Researcher: Good job. Now what's our next job? Sarah: To get six. Researcher: OK. So perfect. But we don't actually need the six because our job is to take them away and not to add them, isn't it? Sarah: yeah Researcher: So we have our sixteen. Now can you take away six for me? Sarah: moves the 6 units away Researcher: So they're gone. So what are we left	Flexible interview

with? Sarah: Ten.	
So what's the first job you want to do there? Sarah: Count up the units. Researcher: So you want to make up your two numbers first, don't you? Sarah: *gets 2 tens and 3 units and 1 ten and 8 units*	Flexible interview
Researcher: (counting the units) One, two, three, four, five, six, seven, eight. Fantastic job. Good one. Now, so you want to bring them together. You want to add the? Sarah: Units. Researcher: Units. So you can take the units and add them up. Sarah: * counts with swiping motion with each unit* 11.	Flexible interview
What about this one? *Hands 14 units over* Sarah:*counts 14 and writes 14 on whiteboard*Researcher: is that the best way you can show me that number? Sarah: *makes a pile of 5+5+4, continues to count the piles with her fingers* 5+5+4! Researcher: good that's really clever. I have another question for you and it's can you swap anything here for anything over here? (pointing to the units and then tens respectively) Could you use these, Sarah, to show me that number? (brings over tens) Sarah: Yeah. *brings one ten over and puts 4 units with it*	Flexible interview
Researcher: Ten. So what does that mean? That ten of these (pointing to units) is equal to one of.... Sarah: Those (pointing to tens rod) Researcher: Yes. And that's because ten units can be shown with the ten, isn't it? Okay. Well done. Great job. Well,	Flexible interview
Researcher: So I think you started with the ten. Sarah: Yeah. Researcher: And then probably started counting up to twenty-one. Now, is that the best way that you can show me that number? Can you write down twenty-one for me again? Is there anything we can swap here? (points to	Flexible interview

units) Can you show me twenty-one in a better way? Sarah: *counts units, then puts one unit beside two tens* Researcher: well done: So how many did you get rid of here? (units) Sarah: these ones (units) Researcher: Oh these ones? Sara: Yeah. Researcher: So you did the swap, so you had ten here. Sarah: Yeah. Researcher: And these ten are the same as that ten (units to tens rod). Sarah: Yeah. Researcher: So you have twenty-one. Well done.	

Sharing Is the mediator interacting in a way that communicates that he/she is on the child's side, that they are working together as a team?

Evidence	Source
Researcher : Good on ya. And last week, you were fantastic, you know that. You did a lot of great work for me. And this week, I want to learn a little bit more about you and your maths, okay? Sarah: Okay. Researcher: So you're going to be telling me a lot about maths, and I'm going to be learning a lot from you. Does that sound good? Sarah: *nods	Flexible interview
Sarah: *counts each of the units and counts one for each 10* 13! Researcher:. So, the first thing you did when you were counting them, was to count the units wasn't it? that was a good plan, and you found that there was how many units? Sarah: 13. Researcher: Let's do it slowly together. So, one. Two.	Flexible interview
Researcher: Now, let me see. So do you know what I liked about what we were saying before the break? It was about going to the shop and swapping in your ten little ones and getting one big ten.	Flexible interview

So that was really, really interesting. And I want to learn a little bit more about that	
Researcher: You did great work for me last week, do you know? You were fantastic. And I found it really interesting. Learning a little bit more about the tens and units. Because I think you did great work with that.	Flexible interview

Verbalising Is the mediator encouraging the child to talk aloud when doing the tasks in order to highlight their thinking?

Evidence	**Source**
S: No. did you find it easy or did you find it hard to explain about the maths and explain how you were doing the maths? Sarah: A little bit of both. S: Oh, a little bit of both. Okay. And when you were explaining it, did that make it easier to understand? Sarah: No.	Student SSI
S: So it was just easier to do it and not have to explain it. And was explaining it nearly slowing you down? Sarah: A little bit. Yeah.	Student SSI
Researcher: So, you can tell me what you're doing, Sarah. What's the first job you're doing? Sarah: I was getting 8 units Researcher Oh, it's a really good plan, I like that. What's your next job?	Flexible interview
Researcher: well done Now, this is the tricky part coming up. You have 8 and you have 14. What's your next job? Sarah: To get the answer. Researcher: Mm, so what are you gonna do?	Flexible interview
Researcher: Okay. This time, can you do that for me? *writes 14+18* So, you have to be the explainer, and can you tell me all about what your plan is here? Sarah: So, I'm getting 4 tens Researcher: So is your first job trying to make a first number?	Flexible interview
Researcher: Okay. Can you show me that?	Flexible interview

Sarah: * gets one ten and 4 units*	
Researcher: Good job. Now whats our next job?	
Researcher: Okay, you can tell me.	Flexible interview
Sarah: *starts counting on her fingers* We usually do it kind of this kind of way.	
Researcher: Can you show me?	
Now I want to see What do you think we have to do here? (takes out “busy at maths second class shadow book, turns to page 9) Sarah: Write the number sentence for each question. How many apples and oranges are there altogether?	Flexible interview
Can you tell me what you're doing, Sarah? Sarah: *starts counting units* I'm getting threes, and then I’m getting another three.	Flexible interview
Researcher: OK, so how many more tomatoes are there than oranges? So, what's the question asking us? Sarah: I don’t know	Flexible interview
S: And I'm just going to ask you to explain everything you do to me again, like you did last time.	Flexible interview
S: In fact, I'm going to change that. (writes 12+13) You can tell me how you're doing it.	Flexible interview
Sarah: *gets 1 ten and 2 units, and gets 3 tens and 1 unit) Researcher: Okay, can you tell me what exactly you've done there?	Flexible interview
Sarah: Thirty. Researcher: Thirty. And come here, you didn't count every single one then, did you? Sarah: No. Researcher: How did you do it then? Sarah: Because I just know three tens make thirty.	Flexible interview
Researcher: And we have 2 sets of 10, I've got 2 sets of 2 of 10, and would you now, to add these up, Sarah, would you count up every single one? (pointing to each block of the tens rod) Sarah: No. Researcher: so how would you do it?	Flexible interview

Sarah: Just by knowing all the 10s what it makes up

Okay, this is your new number, (gives her one ten and ten units) Flexible interview

Can you write that number for me?

Sarah: *counts units, but doesn’t count blocks on 10 rod, writes 21

Researcher: Well done.

How did you get that?

Can

you tell me how you did this? That was really good.

Sarah: I don't really know.

Well done. Can I give you a different one? Flexible interview

Sarah: Yeah.

Researcher: *writes 13-9*

Sarah: Okay.

So what's the first thing you have to do?

Sarah: *writes 6 in units, then writes 5 in tens*

Appendix 35

Full Outline of Pattern Matching and Thematic Analysis for Each of the Five Theoretical Propositions for Case 2 Data.

Proposition 1: MDA will Enhance Domain General Learning Functions Following the Implementation of Mediated Learning Experiences Consistent with the Theory of SCM.

Evidence of empirical patterns consistent with structural cognitive modifiability for domain general learning functions

Inability/Misunderstanding	Mediated Learning Experience	Structural Cognitive Modifiability
Researcher: Okay. This time, can you do that for me? *writes 14+18* So, you have to be the explainer, and can you tell me all about what your plan is here? Sarah: So, I'm getting 4 tens (**flexible interview 1: line 287)**	Researcher: Okay. Which number is which? Can you show me which number is which down here? Sarah: This one is twelve (one ten and 2 units) and this one is thirteen (3 tens and one unit). Researcher: Okay, fantastic. So, this one is twelve because you have one ten and two units, right? Sarah: Yeah. *starts making a change to the other pile and puts one ten and 3 units* **Monitoring (Flexible interview 2: line 848**)	Researcher: Okay, show me. Sarah:*counting on fingers* *Writes 11 down in units section, does not carry the 1 Researcher: 11, okay, so you, oh, Sarah: *corrects herself and writes one and carries the one* Researcher: okay, so you do 11, and what do you do then with the 1? Terrific, great job. **(flexible interview 2: line 990)**
Researcher: Have a look at this one *writes 16+16* Sarah: *counts out 5 tens rods* I need a little bit more tens. Researcher: You need more tens? (clicking) - Okay. Sarah: *counts out 6 tens rods and 3 tens rods, puts them together and starts counting them*		

looks at the materials and pauses Researcher: How are you getting on? Are you getting stuck? Sarah: - Yeah.	
Researcher: Well, okay. So we have 16 and 16. So we did a great job before of making up the numbers. And with the first 16 there, how many tens do we need with 16? Sarah: Six. **(Flexible interview 1: line 119)**	
Context: counting out 14+18 using concrete materials Researcher: Well done. What's our next job? Sarah: add them all up Researcher: can You show me that? Sarah: *counts each of the units and counts one for each 10* 13! **(Flexible interview 1: line 313)**	
Researcher: Okay, so now we have our two 16s. And if we can mix them up and get the answer what do you get. Sarah: *counts the 12 units and the two tens rods* - 14. Researcher: 14? How did we get that? Okay. Sarah: I don’t know **(Flexible interview 1: line 140)**	

Proposition 2: MDA will Illustrate Reconceptualization of Maths Concepts that Follows Mediated Learning Experiences, Consistent with the Theory of SCM.

Evidence of empirical patterns consistent with the structural cognitive modifiability for domain specific learning functions

Does Not Do	Mediated Learning Experiences	Structural Cognitive Modifiability
Sarah is currently having difficulties with multiple strands of the maths curriculum. The class teacher suggests she has difficulty with numeracy in general. She suggests Sarah has appears to have some understanding of elements of numeracy such as place value **(Teacher consultation)** The next part of the abstract level assessment was in the area of place value. Sarah got a lot of these questions wrong. There is no obvious error pattern here that would be suggestive of a certain type of misconception. Perhaps Sarah was unsure of what was being asked of her here. Sarah’s conception of place	Researcher: And we have 2 sets of 10, I've got 2 sets of 2 of 10, and would you now, to add these up, Sarah, would you count up every single one? (pointing to each block of the tens rod) Sarah: No. Researcher: so how would you do it? Sarah: Just by knowing all the 10s what it makes up **implicit help (Flexible interview 2: line 965)**	And so now that you've done that, the new number looks like this. (pointing to the 4 tens rods and one unit) So you have your one unit, you have your two tens, one ten, and another one ten. So what's your answer? Sarah: Twenty. forty Researcher. Forty-one, isn't it? Fantastic. **(flexible interview 2: line 1067)** Researcher: Oh, lovely. Okay, this is your new number, (gives her one ten and ten units) Can you write that number for me? Sarah: *counts units, but doesn’t count blocks on 10 rod, writes 21 **(Flexible interview 2: line 1249)**

value will be explored in the abstract level assessment.

Error pattern analysis

Researcher: Okay, so now we have our two 16s.
And if we can mix them up and get the answer what do you get.
Sarah: *counts the 12 units and the two tens rods* - 14.
Researcher: 14? How did we get that? Okay.
Sarah: I don't know

(Flexible interview 1: line 141)

S: And then we have 10 *referring to the first 10s rod*. So what's 12 plus 10

Sarah: *counts on from 12 pointing to each block of the 10s rod*
21

(**Flexible interview 1: line 147**)

Researcher: Well done. What's our next job?
Sarah: add them all up
Researcher: can You show me that?
Sarah: *counts each of the units and counts one for each 10*
13!

(Flexible interview 1: line 305)

Researcher: Okay, so we have eleven.
So then we wrote down our one.
And when we have eleven, do we have enough to go to the shop to swap it for a big ten?

Sarah: No.
Researcher: Oh, we don't?
Okay, so how many do we need to go to the shop to swap for a big ten?
Sarah: Eighteen.

(Flexible interview 1: line 504)

S: Okay, so what's our next job? You have twelve here and thirteen here.
Sarah: Count them all up.
Researcher: Okay, can you show me how you do that?
Sarah: *counts every unit and each block of the 10 rod*
27!
Researcher: You did loads of counting there, didn't you?
Sarah: Yeah.
(Flexible interview 2: line 851)

Proposition 3: The MDA Procedure will Illustrate Domain General Constructs (Affective and Cognitive) that are Under-Developed, Well Developed and in the Zone of Proximal Development

Evidence of empirical patterns consistent with the zone of proximal development for domain general learning functions

Does Not Do	Does with Help	Does Independently
Sarah: yeah *writes 13* Researcher: Wow, well done, you got that spot on, well done. How did you know that you could show it to me like this? *referring to one 10 rod and 3 units* Sarah: I don't know. **(Flexible interview)**	Researcher: Good job. Now whats our next job?. Sarah: to get, to count up the other number Researcher: Good job. What's our other number called? Sarah: 18 Researcher: Can you show me that? How many tens are in 18, Sarah: One. Researcher: Perfect. Well done. And how many units? Sarah: Eight. **(Flexible interview)**	Researcher: 11! Well done. Can you tell me how you figured that out? Sarah: I just grabbed, I just got some fives and six, and I put them all together **(Flexible interview)**
S: What's so hard about the tens and units? Do you know? Sarah: No. **(Student SSI)**		
And when you were explaining it, did that make it easier to understand? Sarah: No. S: So it was just easier to do it and not have to explain it. And was explaining it nearly slowing you		

down?
Sarah: A little bit. Yeah.

(Student SSI)

Sarah: *counts the 13 units, then places a tens rod with three units*
Researcher: Can you write the number for me?
Sarah: yeah *writes 13*
Researcher: Wow, well done, you got that spot on, well done.
How did you know that you could show it to me like this? *referring to one 10 rod and 3 units*
Sarah: I don't know.

(Flexible interview)

Researcher: did you get that in your head?
Sarah: *nods
Researcher: How did you get that in your head?
Can you explain?
Do you have any idea how you got that?
Sarah: I don't know.

(Flexible interview)

Sarah: *counts units, but doesn't count blocks on 10 rod, writes 21
Researcher: Well done.
How did you get that?
Can
you tell me how you did this? That was really good.
Sarah: I don't really know.

(Flexible interview)

Proposition 4: The MDA procedure will illustrate domain specific (maths) constructs that are under-developed, well developed and in the zone of proximal development

Evidence of empirical patterns consistent with the zone of proximal development for domain specific learning functions

Does Not Do	**Does with Help**	**Does Independently**
Researcher: I think you missed one there, so I think it's eleven. So well done. Okay, so we have eleven. So then we wrote down our one. And when we have eleven, do we have enough to go to the shop to swap it for a big ten? Sarah: No. Researcher: Oh, we don't? Okay, so how many do we need to go to the shop to swap for a big ten? Sarah: Eighteen. **(Flexible interview)**	Researcher: Sarah, have a look at this. Can you count in tens for me, Are you able to count in tens? Sarah: Yeah. Ten, twenty, thirty, forty, fifty, sixty, seventy, eighteen, nineteen, ninety, a hundred. Researcher: Wow, that's exactly right. Well done. So, you can count up in tens. Sarah: Yes **(Flexible interview)**	So, let's look at this one. *writes 5+6* Sarah: *counts out 5 units, then counts out 6 units in separate piles* I'm done Researcher: Okay, what's the answer? Sarah: *counts each unit in both piles* 11! **(Flexible interview)**
Now, I'm going to give you all these things *more tens and units*, I want you to show me how you would do this. *writes 14+8 on the board* Thank you.	Researcher: Then when you put them together like that, which was a great job. How did you know that was 22? Sarah: I don't know. (laughing) Researcher: Did you have to count every one of these? *referring to the individual blocks in the 10s rod* Sarah: Yeah.	Ok look at this one can you make that for me? *writes the number 12* Sarah: *uses a 10 rod and 2 units

And you show me how you would do this. Just the same way you were doing it before. Sarah: ok *starts counting 8 units* Researcher: So, you can tell me what you're doing, Sarah. What's the first job you're doing? Sarah: I was getting 8 units Researcher Oh, it's a really good plan, I like that. What's your next job? Sarah: *gets 4 tens* **(Flexible interview)**	**(Flexible interview)**	Researcher: Oh, wow. How do you know to use this for these straight away? *referring to 10s rod* Have you done that before? Sarah: Yeah. **(Flexible interview)**
Researcher: Well done. What's our next job? Sarah: add them all up Researcher: can You show me that? Sarah: *counts each of the units and counts one for each 10* 13! **(Flexible interview)**	Researcher: Well, okay. So we have 16 and 16. So we did a great job before of making up the numbers. And with the first 16 there, how many tens do we need with 16? Sarah: Six. Researcher: Oh, so, I think we could use maybe six of the units, could we? Sarah: Yeah. Researcher: Okay, so lets count out 6 units. – Sarah: *counts them out* Researcher: Good job. Now how many of the tens goes with the units? Sarah: *moves one tens rod over to the 6 units* Researcher: good job. Now can we do the same thing for the second 16. Sarah: *counts out second 16 with one ten and 6 units **(Flexible interview)**	Researcher: Okay, you ready, here you go. *gives 13 units* So you can put your 10s over here. Okay, so there you have your units. And I want you to tell me what the number that is and then if you can show me how best you can show me that number with your 10s and units. laughing) Sarah: *counts the 13 units, then places a tens rod with three units* Researcher: Can you write the number for me? Sarah: yeah *writes 13* **(Flexible interview)**

Researcher: So, I'm going to show you this one and you can take your tens and units and show me if you couldn't write it out the way you did before, which was lovely, can you do it with the tens and units?
In fact, I'm going to change that. (writes 12+13)
You can tell me how you're doing it.
Sarah: *gets 1 ten and 2 units, and gets 3 tens and 1 unit)
Researcher: Okay, can you tell me what exactly you've done there?

(**Flexible interview**)

Researcher: Oh 4 tens, So, what's your next number? It's 14 isn't it?
Sarah: Yeah.
Researcher: Okay, so is the, which one is the units and which one is the tens?
Sarah: That's the units and that's the tens. *points to the 1 and the 4 respectively*
Researcher: Oh, okay. So, you need 4 units and how many tens?
Sarah: One.
Researcher: Oh, okay. So, you need one 10. Good job.
so we need 4 units.
(**Flexible interview**)

Researcher: Yeah, okay. Ready for another one?
Okay, this is a bit of a tricky one, okay.
Sarah: Okay.
Researcher: Just do your best.
There you go. *gives 21 units
Sarah: *counts 21, gets two tens rods and a unit and places them together
Researcher: Whoa, really impressive that one 'cause I tried to trick you. And you got it right, you got it spot on, you swapped out the two sets out of the 10 *units* and you put in two of these *tens rods*. So, what's your answer?
Sarah: 21.

(Flexible interview)

Proposition 5: MDA will Provide Practical Information to the Teacher in Relation to the Student Informed by Theories of ZoPD and SCM

Thematic analysis of teacher and SET semi-structured interviews

Expectations for External Support
S: And what would your expectation be? T: So if a psychologist was to come in, for example? Well, that they would give you specific recommendations that you could give in the class T: Yeah, I get what you're saying. Yeah. So, I mean, obviously, this is a bit more specific. So sometimes you come with a score and okay, it's basically, you hadn't a score before, but you knew they weren't where their peers were. So it doesn't really help. It's not that beneficial. And maybe it's needed on paper, and you need that. But what you really want as a teacher is to know, where are the specific difficulties and how can I help? But you need that in a very simple way. You know, we're like the children we just need. I don't want to have to read 10 pages to find the answers. If somebody can come in and say, well, look, this child needs this.

Contact Time
T: No, I think this is better, because this is more, this is going to be more beneficial, because yes, coming in, I mean, I've been through the system so many times where a psychologist comes in, completes the test, we get the report, but the report doesn't tell us anything different than we already knew. And the recommendations are what we're already doing. And sometimes it has that feeling of cut and paste. So something, because we're dealing with somebody that's just this individual child with these very specific individual problems. So somebody that comes in and works one-to-one over a course of time is definitely going to know that child like we do. And we'd be able to share those ideas. And I think obviously something longer term, but I don't know how that would work out time-wise financially.